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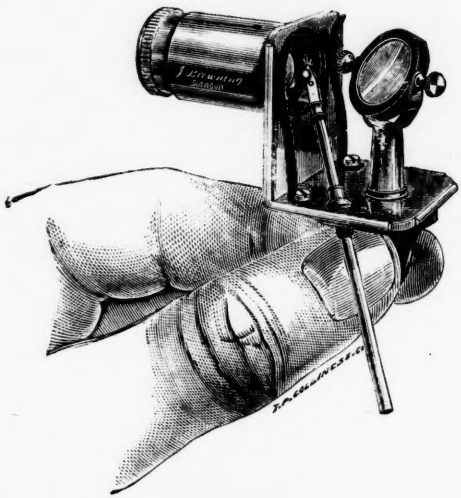

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JOURNAL OF SCIENCE.

APRIL, 1879.

I. IS NATURE PERFECT?

WE have often thought it might be useful to exhibit, in all their well-marked contrast with the results of modern Science, those views of Nature which still prevail even among the cultivated classes, and which are very slowly retiring from the fields of literature. For this purpose let us take a man,—such as may be found in abundance in the middle and upper ranks of society,—well-educated, heedful, thoughtful, and refined, but not trained as an observer, and having no special acquaintance with recent discoveries in natural history. Let us give him a holiday, and send him for a summer ramble in the New Forest, in "merrie Sherwoode," or among the ferny coombs of Devon, and let us try the while to read his musings. Even his very first expression of feeling, the sigh of relief on finding himself rid of city-bustle, worry, and noise, is mainly the outcome of an illusion. He fancies himself in a sphere where boundless resources are dispensed with a liberality equally boundless. The heavens are full of light and warmth, and the earth is clad in rich and varied hues. Perfume breathes from every spray. On all sides is life, animal and vegetable, unworn by toil and unshadowed by care and anxiety. To the butterfly hovering over the blossoms, to the blackbird warbling on the spray, the world seems not as to man, the task-yard of a workhouse, but the banqueting-hall of a palace. The observer, even whilst he envies the insects and the flowers, who "toil not, neither do they spin," feels soothed and refreshed by the mere reflection of their supposed felicity.

Plenty requires peace as its natural complement, and our wanderer believes that he finds this boon also in the wood-

lands and the heaths. Indeed, how should it be otherwise? Where there is superabundant plenty, where every demand is more than satisfied, how should there be the thrusting, and pushing, and jostling, outward visible signs of that internecine war of each against all, and of all against each, which the "friends of peace" worship under the name of competition? The observer cannot, indeed, forget that in his realms of concord and repose, pain and death are present. He knows that at any given moment hundreds of flies must be struggling in the snares of spiders; that caterpillars innumerable are being gradually devoured by internal parasites; that many a song-bird is falling a prey to the hawk or the weasel. But, as was the case half a century ago even with eminent naturalists, he scarcely apprehends the full meaning of all this suffering and massacre. Such facts as we have just enumerated seem to him mere "rude exceptions to the general joy," departures from the order of Nature, casual, even though numerous, rather than as they really are, part and parcel of its very essence. Our friend in his ramble, and in his necessarily hasty survey, fails to perceive that not only does one-half the animal kingdom live only in virtue of the death of the other half, but that the herbivorous creature is as much a life-destroyer as the beast of prey, extirpating other animals by depriving them of food, and plants by consuming their seed or their seedlings. He overlooks the silent, quiet, but not the less deadly war waged by plants among themselves, each seeking to monopolise to itself soil, air, and light, and to crowd out, starve, or smother its competitors. In short, in his optimist contemplations, he entirely forgets that struggle for existence which—whether or not we regard it as a main factor in the development of animal and vegetable forms—we are bound to accept as perhaps the greatest, and assuredly the saddest, feature of the organic world. Who, after reading the third chapter of the "Origin of Species," can fail to be reminded of those words of St. Paul "For we know that the whole creation groaneth and travaileth in pain together until now;"* or of the sadder exclamation of one who, having no faith in the ultimate solution of this dark riddle, cries out in agony "Creation is murder!"†

But not only is strife rather than peace the order of the organic world,—strife so thoroughgoing and so widespread that it rages even among spermatozooids; not only do the

* Romans, viii. 22.

† Winwood Reade, Martyrdom of Man.

majority of seeds and ova, from one or other cause, fail to be developed; not only does every species press hard on its means of subsistence, or on the space where alone its being is possible. Even in matters where life is not directly concerned we find Dame Nature not lavish, not liberal, but more penurious than the wife of the thriftiest peasant-proprietor in rural France. Those colours which so fascinate the poet or the artist, and which seem to be spread in such royal lavishment over copse and meadow and heath, have all their purpose to fulfil; they have to serve as an attraction to insects which effect the fertilisation of the flower. The beauty and the odour which we so much admire appear only when this task is necessary, and when it is accomplished they are again withdrawn, just as at a banquet the lights are quenched and the decorations taken down when the guests have departed.

To a sensitive mind it must be saddening to find that the woods, the fields, and the solitudes offer no soothing contrast to the exchange, the workshop, or the battle-field, and that on earth peace, repose, and harmony exist nowhere. But it is the duty of Science to "perceive and declare" whether the facts and the laws recognised be joyous or grievous.

In one sense, indeed, Nature may be called lavish. But it is an unkindly prodigality. She is reckless of life; reckless and wasteful, too, of heat, the prime condition of organic existence. Passing over the fact that the bulk of the solar radiations travel out into the desert depths of space, while an infinitesimal portion alone falls upon any of the planets, very much of the heat which reaches our earth, at least, is radiated off again during the night. Carbonic acid gas, indeed, possesses the precious attribute of admitting the sun's rays freely, and of being at the same time almost impervious to heat-rays of low tension, such as those given off by the earth. But this gas forms but a very small proportion of our atmosphere, and could not be sensibly increased on account of its injurious action upon higher animal life. But if the non-poisonous gases oxygen and nitrogen had the same power as regards the radiation of heat, the climate of the world would be much improved, and spring frosts—the bane of the farmer and the gardener—would be rendered impossible. It is of course conceivable that some cause may exist which renders it impossible for oxygen and nitrogen to possess this attribute without forfeiting their characteristics in other respects.

There is another feature which, outside of scientific circles, we hear commonly ascribed both to the individual

animal or plant, to the fauna and flora of any given country, and to the animal and vegetable kingdoms in their entirety. We refer to the attribute of "perfection." We must confess ourselves utterly at a loss to know how this notion has been reached. We have asked believers in this doctrine to tell us by what marks this perfection is to be recognised. We have invited them to take up a plant or an animal, and to demonstrate that any departure from or addition to its present standard, whether structurally or functionally, would be injurious. But the only answer we have received has been a cloud of generalities. The very idea of perfection seems to us unthinkable in reference to a crowd of species engaged, as all Nature is, in mutual conflict. It is by dint of the imperfections of the Carnivora in speed, strength, or cunning that their prey—say the deer or antelope—escapes. It is in virtue of the imperfections of the latter animals that they are captured by the wolf or the leopard. Again, were all animals and vegetables perfect in themselves and in reference to their surroundings, we may ask how it comes that so many species have been exterminated, and that others are even now in course of extermination? It may be contended that the surroundings have altered. This, then, is an admission that the adaptation to circumstances is not always perfect. But further, some other species, or at least groups, coeval with such as have disappeared, are still found surviving. Here we have consequently the following riddle to solve:—Two groups of "perfect" animals, each in "perfect" harmony with its surroundings, are given. These circumstances being altered, the one group is no longer in harmony, and consequently perishes, while the other remains equally well adapted to a different set of conditions, and survives! Yet more; admitting the perfection dogma, we must suppose the fauna and flora of any region—say New Zealand—better adapted to its soil and climate, and to all other local conditions, than any strange animal or plant can be. On introducing such strange species we should therefore see them placed at a disadvantage, and without constant human aid and supervision prove unable to exist at all. But in reality the very reverse is the case; the new comers are not only found able to exist independently of man's assistance, but to spread in opposition to his most strenuous efforts, and even to crowd out the natives. The notion, therefore, that every local fauna and flora forms a perfect whole, perfectly adapted to the circumstances in which it is placed, must be given up as a most glaring error.

Again, we often see large groups of closely-allied species, differing but little from each other, inhabiting the same country, dependent upon the same kind of food, and exposed to the same enemies. Thus there are in Britain alone fifty-seven species of the small dung-feeding beetles included under the genus *Aphodius*. Some of these are exceedingly abundant, others comparatively rare. If all these species are perfect, and perfectly adapted to their environments, why should some be so much more plentiful than others? But, descending more closely to particulars, we may show that in animals, as in man himself, there are certain *desiderata*—wants which Nature has left unsupplied. How exceedingly uncomfortable should we, for instance, feel if we were suddenly deprived of the power which we now enjoy of excluding the light from our eyes when we think proper! Yet as regards the sense of hearing we labour under a similar deficiency; it might rather be said under a greater, since to all persons who have occasion to concentrate their thoughts upon some given subject noise is a far greater nuisance than light can ever be to a healthy man. Surely, then, our inability to render ourselves temporarily and voluntarily deaf is a proof that we, in one respect at least, fall short of perfection.

We may take another instance: what a great addition would it be to man's comfort if he were personally offensive to all insects of the Dipterous order, so that they would keep aloof from him in disgust! When we consider that the mosquito, in addition to the positive irritation, annoyance, and want of sleep which its attacks occasion, is now proved to be an agent in the spread of leprosy,—when we remember that the common house-fly is a propagator at least of ophthalmia, and probably of all zymotic disease,—we surely cannot dispute that such a change, either in the nature of our cutaneous emanations or in the tastes of these pests, would be an incalculable boon, lacking which we cannot proclaim ourselves physically perfect.

Did we know the necessities of other animals as well as we know our own, we might doubtless find in like manner defects on all hands. But we have surely said enough to lead the advocates of organic perfection—who often find in this dogma an *à priori* objection against Evolution—to pause and reconsider the evidence upon which it is based.

The last of the popular assumptions concerning Organic Nature which we can here notice is the old, but still rampant notion that every plant, every animal, exists with reference to man, and for his convenience. "What use is

such or such a creature?" is a question too commonly asked —and not by children only—of the zoologist or the botanist, When we reply that to the best of our belief and knowledge the animal or plant in question is of no use, but simply an unmitigated nuisance, the most charitable construction put upon our answer is that we are too proud to confess our ignorance. Like the doctrine of organic perfection, this dogma is not easily traceable to any substantial basis, but, having once become a current article of popular faith, its extirpation is proving a difficult task. To us it appears, in its very essence, irreverent. If the Creator had, *e.g.*, made the mosquito, or the guinea-worm, or the *Lucilia hominovora* to be of service to man, we may depend upon it that they would not have been sources of annoyance. Even a human invention, the produce of exceedingly finite reason, is condemned if, along with certain and even great good, it effects abundant mischief. How much more if the good be problematic, and the evil open and palpable? Shall we, then, adduce what is notoriously defective as an instance of Divine "contrivance"? One thing we may certainly conclude, viz., that if a maximum of earthly enjoyment and the minimisation of earthly suffering had been the objects of the Creator the world would have assuredly been constituted very differently from what it is. When we know what His objects really were it will be quite time enough to indulge in teleology and to indite "Bridgewater Treatises."

II. THOUGHTS ON OUR CONCEPTIONS OF PHYSICAL LAW.*

By Prof. FRANCIS E. NIPHER, St. Louis, Mo.

IN the short time at my disposal I wish to point out some reasons for the more general cultivation of a certain cardinal virtue which is so rare that I fear it has no name. Perhaps the words *Intellectual Modesty* would come as near as any others in expressing what I mean. The

* Abstract of an Address before the Alumni of the State University of Iowa, June 19, 1878; delivered at Kansas City, December 23, 1878, and which appears in the "Kansas City Review."

world is very full of people who are ready to make assertions upon subjects which are evidently too difficult for them—in many cases too difficult for any one—to handle with any degree of certainty; and it doubtless often happens that some who have meditated studiously for years upon some such subject, arriving at no satisfactory conclusion, are regarded as objects of profound commiseration by others, who rush upon conclusions like the unthinking horse into the battle. It is as natural that people should thus differ as that some should have darker skins, taller frames, or more irritable tempers than others. To what extent these, and other differences which we shall point out, are blameworthy, we cannot attempt to discuss, but shall study the mental habits of men in precisely the same spirit in which we would study the habits of other animals. But I wish to show some tangible reasons for thinking that there are very few subjects upon which we can dogmatise, and that in any case it is unnecessary. I wish to advocate the cultivation of intellectual modesty, not merely because it seems to me to be one of the brightest ornaments of the human mind, but because of its vital connection with another cardinal virtue—intellectual honesty.

Perhaps this end will be best attained by considering the difficulties which are met in the investigation of any subject, when the sole aim is to find out the truth of the matter, and I have thought it proper to point out some of the difficulties to which we are subject in arriving at our conceptions of physical law.

The study of physical science has endowed the human mind with an attribute which is usually ascribed to and is thought to be characteristic of the Divine Mind. I refer to the power of prophecy. The astronomer can predict the position of the planets for generations to come, basing his predictions on the assumption—an unproved assumption—that only those causes which he has considered will act in the future, or, in other words, that the present order of things will continue. His power of prediction does not, however, extend indefinitely into the future, for there are doubtless many minor disturbances or perturbations, too small to be detected by the instruments which he can command, without many centuries of observation, the effects of which will become plainly apparent after the lapse of ages, —that is to say, his power of prophecy is limited by his ignorance of certain facts, and possibly by his inability to solve the equations involved in a complete discussion of the subject.

It is for precisely the same reason that we cannot foretell the future destiny of every person in the world. But to a mind possessing all knowledge, and of infinite power, the one problem would evidently be as simple as the other.

Not only are we unable to predict for an infinite future, on account of the summing up of disturbances which cannot be detected in a short time, with our means of investigation, but, as before suggested, events wholly unexpected to our partially instructed minds—apparent breaches of continuity—are liable to happen at any time.

"A great explosion on the sun may scorch us into cinders in a second. The earth may be dashed to pieces and dissipated into gas, by collision with some immense meteorite. We may become involved in a nebulous atmosphere of combustible gas, which would ignite a moment later; in fact, as was so eloquently pointed out by Mr. Babbage, there is no catastrophe too great or too sudden to be consistent with the reign of law and the continuity of action."

In the discussion of physical phenomena we always ignore the greater part of the discussion, by neglecting those elements which are, or are supposed to be, unimportant. In so simple an operation as the weighing of a quantity of matter on a steelyard, we can discuss only the merest elements of the case. The student of physics would tell you that the weights are inversely as the lever arms, but this is far from being the whole story. During the weighing, certain parts of the steel bar are heated; other parts are cooled; still other parts retain their temperature unchanged; electrical currents are set up within its mass; its magnetism is changed; its torsion and elasticity become different: in fact, to discuss all the changes occurring within the bar during so simple an operation would infinitely transcend the power of the most gifted men.

If we could discuss completely the laws which govern phenomena we should find them represented, in many cases, not by the comparatively simple formulæ which have been found sufficient for practical purposes, but by infinite series, the first terms only of which our mathematicians have been able to deduce, and our physicists to experimentally detect.

In the study of Physics our most certain experimental results force us to ideas equally beyond our power of realisation. It is shown, beyond question, that light moves over a distance of about seven times the circumference of our earth in a single second. We must look for something marvellous in any theory which can account for so marvellous a fact. According to Newton's theory, we should have

particles of light shooting off from a distant luminous body with this immense velocity, and, falling upon a mirror, their motion would not merely be checked, but the elasticity of these light particles must be assumed to be so perfect that they rebound with an equal velocity.

According to the undulatory theory, the light consists of vibrations of a medium which fills all space. Since the velocity of transmission of these vibrations is so great it follows that the elasticity of this medium must be 10,000,000,000 times as great as that of the hardest steel. Space is not now regarded as a void, but is filled with a medium which, as Thomas Young remarked, "is not only highly elastic, but absolutely solid." And yet, as we walk through space, the solid atoms which compose our bodies experience not the slightest resistance. Such ideas, although they can be conceived, cannot be realised. We have had no previous experience with materials possessing such properties, and such ideas must necessarily appear strange to us; but they are no more strange than the phenomena of light which we directly observe, and which force us to this or to some other theory equally marvellous. Only those who have carefully examined the subject can realise how weighty is the evidence in favour of the undulatory theory of light; but where such stupendous conceptions are involved, a slavish acceptance of any theory, even by them, would be in the highest degree objectionable. We are not the friends of theories, but of truth.

It is not surprising, then, that in the progress of our sciences many errors of reasoning and in the interpretation of facts have been committed. You are all familiar with the ideas of Newton in regard to the nature of light, ideas which were not in themselves absurd, which were firmly believed in by this man of such transcendent power, but which were clearly negatived by results of subsequent experiment.

Lavoisier's idea that all acids were compounds of oxygen received a complete refutation when the constitution of prussic and muriatic acids became known. In fact the errors of scientific men are well-nigh innumerable, not because they are men of science, but because they are *men*, and we are probably justified in saying, quite in general, that if the man who never committed a mental blunder be found, we shall also find a man who never conceived a vigorous thought. The fact that the results of scientific men can usually be checked by observation and experiment perhaps diminishes their liability to err, and enables them

to discover multitudes of errors that would otherwise escape their attention. This does not tend to make the results of their investigations less weighty than results which have been reached by other processes more purely mental. If men of science, with their severe methods of research, their habits of testing their conclusions by observation and experiment, are nevertheless led into wrong conclusions, what does it prove? Simply that the human mind, even under the most favourable circumstances, is fallible! Is there a class of men less liable to make mistakes? It is precisely this experience which causes many to place a small value upon the unsupported assertions and speculations of any man, however honest, earnest, or able he may be.

On this point one of the most admirable of experimenters, Faraday, has beautifully said—"The world little knows how many of the thoughts and theories which have passed through the mind of the scientific investigator have been crushed in silence and secrecy by his own severe criticism and adverse examination; that in the most successful instances not a tenth of the suggestions, the hopes, the wishes, the preliminary conclusions, have been realised."

In the 24th series of his "Experimental Researches" Faraday describes many tedious and intricate experiments, in which he tried to connect gravitation and electricity. "He laboured with characteristic energy for days, on the clock-tower of the Houses of Parliament and in the shot-tower of Southwark, raising and lowering heavy weights connected with wire coils. Many times his great skill as an experimenter prevented him from being deceived by results which others would have regarded as conclusive proofs of his idea, and when the whole was done there remained absolutely no result." For although the results were wholly negative, Faraday could never accept them as conclusive against his idea, to which he had been led by his experiments on the relations between electricity and magnetism. His mental condition after this work was done is best described in his own words:—"Occasionally, and frequently, the exercise of the judgment ought to end in *absolute reservation*. It may be very distasteful, and great fatigue to suspend a conclusion; but as we are not infallible, so we ought to be cautious."

It is a matter of common observation that men who, like Faraday, have done much to widen the boundaries of our knowledge, are precisely the ones who are most frequently in a state of doubt, while those who have received all their knowledge at second hand are generally more ready with a

positive decision and a reason for it, not necessarily because their intellectual integrity is less, but because they *cannot* realise how vain a thing the human reason is. To imagination and reason, controlled and checked by experiment and observation, are we to look as the source of the greatest advancement in science; but we are not to look for infallibility, and in cases where the reason alone is allowed to decide, where observation and experiment are impossible, the uncertainty must necessarily be greater. In many cases the fact that the subject is so intrinsically difficult that no experimental check is possible, appears to inspire the investigator with a confidence in his conclusions that could hardly be reinforced by absolute certainty.

I have confined myself to the errors which scientific men have committed, and to which they are liable in their search for truth, not because they alone are liable to err, but because a discussion of the multitude of errors into which intellectual men of other professions have fallen would be sure to give offence. But it is not the scientific mind which stands impeached—it is the *human* mind!

To what end have we then come? It appears that all scientific results are attended with some uncertainty. Sometimes the uncertainty is very small, and we are able to obtain a numerical estimate of it. In other cases it may be possible that a fundamental misconception of the truth may have been formed. As an instance illustrating what I mean we may cite the case of the measurement of the Atlanta base-line by the engineers of the United States Coast Survey. The whole length of the base-line was nearly 6 miles, and three determinations of its length showed differences of about 3-10ths of an inch—about a millionth of the entire length. It is safe to say that if these remeasurements had shown differences of 10 feet there would have been no quarrelling in regard to which measurement was right, but all would have been rejected; and if the engineers were not dismissed as incompetent, they would, with feelings of mortification, have begun their work over again. It is curious to observe that in many cases where less skilful men attack problems infinitely more complex, reaching conclusions differing as widely as the poles, we have, instead of conscientious re-investigation or a modest reservation of judgment, dogmatic discussions, empty words. In the other case, where the error is likely to be a fundamental one, the probability of the truth or error of a conclusion cannot always be determined numerically, and will vary greatly in different minds.

In conclusion, allow me to say that it seems quite probable that human welfare does not require us to sit in judgment on the ideas of others. Thoughtful men are becoming more and more impressed with the vastness of the unknown and the comparative insignificance of human achievement, while the demonstrated fallibility of human reason leads them to temperance and modesty of thought and expression: to *appreciation*, as well as toleration, of opposition and doubt. Certain it is, that if we preserve our intellectual integrity we shall be unable to settle many of the problems that interest us most. If we decide upon some of them, and other persons still reserve their judgment or decide differently, we need not lose our tempers; they have not only decided differently from us, but we have also decided differently from them. It is important to notice that neither of these decisions has affected the *truth* in the least. If we feel called upon to defend the truth, we are, after all, only defending what we *believe* to be truth, and possibly against men as honest and as able as ourselves. But why should we defend the truth? So long as the heart of humanity shall pulsate, will not truth be cherished there? Why would it not be far better for each one to put himself in the attitude of a reverent *searcher* for truth? remembering always that the little decisions that we may reach are possibly wrong, that all of the honesty and ability in the world is not concentrated within ourselves and the comparatively few who think as we do, and that one can do nothing nobler than to make himself as intelligent and humane as possible, resolutely following out his highest convictions, and living at peace with himself and with all men.

III. THE OLD STANNARIES OF THE WEST OF ENGLAND.

By James Quick.

IT is a remarkable fact, though unnoticed by most writers of English history, that there existed in England for many centuries an assembly which held the regulation or supervision of all matters connected with what was for a long period the most important branch of English commercial enterprise. Yet such was the case. The privilege of making laws for the direction of tin mining in the West of England was enjoyed by two convocations designated

the Parliaments of the Stannaries, and which were composed of representatives elected by the miners or "tinners," as the workers in the Cornish and Devonshire mines were until within about the last fifty years commonly called. A Stannary Parliament used to meet at a place called Hengiston Down,* subsequently at Lostwithiel, and later on at Truro, to legislate for the Cornish tin-mines; and another at Crockern Tor,† and in the middle and later ages at Tavistock, for those of Devonshire; the Members of the Parliament for the former county being styled "Stannators," and those for the latter "Jurats." These Parliaments, which in some form appear to have existed from time immemorial, and probably originated in gatherings of the miners to discuss the prospects of their trade, and later on perhaps used to meet to demur at the enormous and oppressive dues levied from them by the Crown, acquired in the Middle Ages a very large amount of power over the mining interest. To become law a Bill for regulating mining affairs required to be signed by each Member of the Stannary Parliament before which it was brought, and then by the Lord Warden of the Stannaries, and by the Sovereign or Prince of Wales in his capacity of Duke of Cornwall, and as such the head of Stannary affairs.‡ During the last three centuries, too, the King or Duke could not make any law for the Stannaries without the consent of the twenty-four Members of either Parliament,‖ and in 1752 (see note p. 284) it was enacted that a Bill brought into the Cornish Stannary Parliament required, to become law, to receive the assent of sixteen members of the Parliament.

For the administration of the laws made by the Stannary Parliaments there were at different places Stannary Courts,§ and "in all matters of complaint the tinners

* Near Callington. † On Dartmoor.

In the eighteenth century Mining Committees were occasionally opened at these places and adjourned to a Stannary Court town. (See note § below.)

‡ This was according to an old Charter of Edward III., which was the most important and implicit of any in its grants to tinners.

‖ This was according to a Charter granted by Henry VII., and called the Charter of Pardon. Much of the information above given about the Stannaries has been taken from "A State of the Proceedings of the Convocation or Parliament for the Stannaries of the County of Cornwall, held at Lestwithiel, Jan. 29, 1750, &c." by a Cornishman; London, 1751 (see pp. 2 and 3). No Parliament appears to have previously met since 1710. See also Sir Jno. Dodridge's "History of the Ancient and Moderne Estate of the Principality of Wales, Duchy of Cornewall, &c." London, 1630.

§ The old Stannary Court and Coinage towns in Cornwall were Launceston, Lestwithiel, Truro, and Helston, and, after 1811, Penzance. In Devonshire they were Plympton, Ashburton, Tavistock, and Chagford. There were Stannary prisons at Lidford and Lestwithiel. The Stannary districts in Cornwall were Foweymore, Blackmore, Tywarnhaile, Penwith, and Kerrier, each of which sent six members to the Stannary Convocation.

were judged by their own laws before the Judges of the Stannaries," and they were "exempt from all other jurisdictions of the kingdom in all causes within the Stannaries amongst them, except in such as affected land, life, or limb." They were also exempted from serving on juries other than those connected with the Stannaries, from paying tithes to the clergy out of their wages, and could sell their their own goods at fairs or markets without paying any fees. The Stannary Courts were held every three weeks, and a Court was held once every month by a Vice- or Sub-Warden to hear cases brought from the other Courts; and from the decision of this Court there was no appeal, save to the Lord Warden, the Duke in Council, or the King in person.

The history of Stannary matters prior to the seventeenth century, owing chiefly to many valuable records having been destroyed during the Civil War, is very obscure, but during that and the following century the Stannary Parliaments were extremely active. The memberships appear to have been regarded as posts of considerable importance, and to have been eagerly sought after, possibly with some sinister motive of ulterior gain, for during those centuries a large amount of underhanded dealing in Stannary affairs seems to have been practised. The writer of an account of a Cornish Parliament which met in 1750 (see note ‖ page 283) remarks that "during the time of an election gentlemen think it worth while to come down into the county who were never seen in it at any other time, and to neglect their business and the pursuit of their affairs for three months together, without having or pretending to have the least knowledge of tin or Stannary matters." The same writer also remarks "that whoever will take the pains to search into it will find the constitution of the Stannaries to be as well established, both by Charter and Act of Parliament, as any particular constitution can be, or even as the constitution of the kingdom itself." Little could he have thought that, within another century from the time he wrote, the Stannary Parliaments, together with most of the ancient customs and privileges of the tinners, would have fallen into desuetude, and that the Stannary Courts would have merged into a single restricted tribunal, with every prospect of that being soon combined with the County Court. Probably the last of the Stannary Parliaments was the one that assembled at Truro on 13th September, 1752.* In

* The laws made by this Parliament are given in "Laws of the Stannaries of Cornwall, &c.," published by order of the said Parliament, 1752. In 1752, also, the laws made 22 Jac. I., 12 Car. I., and 4 Jac. II. are confirmed.

1837 the different Courts were consolidated into one Court, which now periodically meets at Truro, and exercises in many respects similar jurisdiction over Stannary matters to that of the Courts of Chancery, Common Law, and Equity over others. The right possessed by the monarch of pre-emption, or of buying any tin raised in the two counties at his own price and in preference to anybody else, and often exercised in the Middle Ages to a very oppressive extent, was, together with many other Stannary prerogatives, abolished by two Acts passed in the reign of William and Mary,* whilst the dues on tin payable to the Duchy of Cornwall were only cancelled so late as the year 1838.†

One of the oldest and most extraordinary privileges of the West of England tinners was the very widely observed custom of "bounding," which may perhaps remind our readers of the practice of "beating the bounds" still observed by many municipal authorities in England. In Cornwall and Devonshire all land was formerly considered either as being in "severall" or in "wastrell," the former term being applied to lands enclosed or built upon, and the latter to those lying waste or open. By the "bounding" custom any person might enter upon the "wastrell" of another, and mark out by four "boundaries" any certain area. A written description of the land bounded, and the name of the "bounder, had then to be recorded in the nearest Stannary Court, and a notice given to the owner of the soil. The "bounding" had then to be proclaimed in three successive open Courts, and if no objection were raised against it a writ‡ was given to the bounder, investing him with the exclusive right to search for and appropriate to his own use all tin or tin-ore found within the described limits, upon the condition that he pay to the landowner (in Cornwall) a fifteenth part in kind of the quantity of tin raised. The four corners of the land bounded were generally marked by a pole being erected at each, with a furze-bush at the top, and it is told amongst the miners that on May-day

* 1 Wm. and Mary, c. 30, and 5 Wm. and Mary, c. 36.

† By Act 1 and 2 Vic., c. 102, which substituted for the dues an equivalent sum payable from the U. K. Consolidated Fund. For further particulars on this point see Appendix to the Stannary case of Vice *v.* Thomas (London: Saunders and Benning, 1843). The Stannary duty in Cornwall from the time of Richard Earl of Cornwall (granted to him by Charter in 11th of Ed. III.) had been 40s. for every 1000 wt. of tin raised, and in Devonshire from time immemorial 15s. 6d. for every 1000 wt. of tin raised. There was also a custom of stamping or "coining" each block of tin raised and smelted in the district with the Duchy arms. This was also abolished in 1838.

‡ Several of these are still in existence. One is preserved in the Museum of Practical Geology, and Royal School of Mines, Jermyn Street.

mornings the poles used to be decorated with flowers,* and that youths and maidens used to dance around them.

The right of bounding, which could be disposed of by the possessor in the same manner as other property, might be preserved to an indefinite period, either by actually working the land and paying toll, or by annually "renewing" the four boundary marks on a certain day, by performing the operation of cutting a turf a square foot in size, and piling thereon some loose earth in the form of a mole-hill,† at each corner of the land bounded. Neglect to renew the bounds in any one year forfeited the right to them, and evidence before the Equity Law Courts of recent years‡ has confined the area boundable to narrow limits, although such limits have never been accurately defined. As to the origin of the bounding custom we incline to the opinion of Dr. Borlase,‖ that the privilege was granted for the encouragement of the tinners. Possibly it may have been at first confined to the "wastrell" land of the King, who would, of course, derive benefit from such land being worked for tin, and afterwards became applied to all wastrell. It soon, however, grew to be a very oppressive custom for the ordinary landowner. The injustice of one man being able to prevent another from raising the tin that might be in the latter's ground was certainly very great, and it is a matter for surprise that anyone upon coming into possession of land in Cornwall did not at once take up his own bounds, for we cannot find any Cornish Stannary Law which confined the holding of bounds to the tinners. The bounding custom in Devonshire differed from the custom of Cornwall in that the tinner could search in "severall" as well as in "wastrell," and was not compelled to pay any toll or compensation to the lord of the soil. Tin-bounding in the two counties has now, however, been in disuse for many years, and no mine at present worked is held under its tenure.

* It is stated in a footnote at p. 318, vol. iii., of BRAND'S Antiquities, that the poles were decorated with flowers on St. John's Day. An old miner told the above-given particulars to the writer of this paper.

† See PRYCE, Mineralogia Cornubiensis.

‡ Further particulars of the bounding custom in the West of England will be found in a Treatise on the Laws relating to Mines, by R. P. COLLIER, Barrister-at-Law, &c. (London, 1849), which work is a valuable digest of Stannary Law. See also Britain's Metal Mines, by J. R. PIKE (London, 8vo., 1860); also PRYCE'S Mineralogia, pp. 137—139, and BORLASE'S Natural History, p. 167. The Charter which principally confirmed the privilege was one of 33 Edward I. (A. D. 1305), and others referring to the custom are still extant.

‖ See his Natural History of Cornwall, Oxford: 1758.

IV. A NEW THEORY OF TERRESTRIAL MAGNETISM.

By Profs. PERRY and AYRTON.

AT the meeting of the Physical Society on the 7th inst. Mr. Ayrton explained, on behalf of Prof. Perry and himself, a theory of terrestrial magnetism which has the great novelty that it makes the existence of the earth's magnetism depend solely on the earth's daily rotation, and does not require, as do all other theories based on electro-magnetic phenomena, the existence of other bodies in the universe. In fact, they have arrived at the result that if any body of any material has a static electric charge, and if it rotates about an axis, then *per se* there will be a magnetic field in the interior of this body as well as in the neighbourhood outside.

In 1876 Mr. Rowland, working in Professor Helmholtz's laboratory, proved experimentally that a quantity of electricity in mechanical motion acted like an electric current in deflecting a magnet, and it is on this result that Profs. Perry and Ayrton have based their whole theory. For they point out that since the points near the surface of the earth have different linear velocities from those in the interior (although all the points have the same angular velocity of rotation round the earth's axis), it follows that if the earth had an initial electrical charge, residing of course in accordance with the well-known electrical law, on its surface, the electrified particles would have velocities relative to the remainder; hence, as a direct consequence of the results of the experiments published by Professor Helmholtz, the interior of the earth would be a magnetic field, quite independently of its interior constitution, and precisely similar reasoning, of course, proves that outside the earth's surface there would also be a magnetic field.

In order to solve the difficult problem of determining the electro-magnetic potential at any place, they have calculated the magnetic forces produced at any point, first by the rotation of a small electrified area on the surface of the earth, and then, by summation, the force produced by the rotation of the whole electrified surface; and they have shown that these forces are the same as would be produced by certain definite distributions of attracting matter over the earth's surface, from which, by the use of spherical harmonics, they have arrived at the conclusion that if the earth had an angular

velocity of rotation around its axis w, and a uniform electric density σ, then there must be an electro-magnetic potential at any point inside the earth equal to—

$$\frac{4\pi}{3} 2\sigma w r \cos\theta,$$

and at any point outside the earth—

$$\frac{4\pi}{3} 2\sigma w \frac{1}{r^2} \cos\theta,$$

where the unit of length is the earth's radius, r the distance from the earth's centre of the place in question, and θ its co-latitude.

Now this electro-magnetic potential will be accompanied with certain magnetic forces varying from point to point, and the magnitude of these forces will depend on the interior constitution of the earth. As an example of their conclusion they examine what would be the distribution of magnetic intensity if the earth consisted of a hollow iron shell, and they have, using Poisson's formula, arrived at the following result :—If such an iron shell has an initial uniform charge of static electricity, and if it has an angular velocity of rotation round a diameter, then, independently of all other bodies in the universe, and independently of the coefficient of magnetisation of the iron, there will be at any point on the surface of the sphere, having a latitude λ, a magnetic force proportional to—

$$\sqrt{1+3\sin^2\lambda}.$$

But this result is the same as that given by Biot's well-known law for the distribution of magnetic intensity on the earth's surface, hence giving considerable probability to their theory.

It is important to notice that in previous examinations of the earth's magnetism it has been usual to start with the known law of distribution of magnetic intensity, and then deduce what arrangement of magnets, &c., inside the earth would lead to this distribution; but in this new theory of Profs. Perry and Ayrton they start merely with an experiment described by Prof. Helmholtz, of the effects of a rotating electrified body, and show from this that the earth by its rotation alone *must* be magnetic, and next prove that if there be an iron shell, thick or thin, in the earth then the distribution of magnetic intensity on the earth's surface will be the same as is known to exist from observation.

Next as regards the sign of the electric charge on the earth's surface required to produce the earth's magnetic polarity—Is it in accordance with the known phenomena of atmospheric

electricity? To produce the earth's magnetism we must have, in accordance with the known laws of electro-magnetism, a *negative* current flowing from west to east or in the direction of rotation of the earth. In the language of the new theory, therefore, the surface of the earth must be *negatively* charged, but Sir William Thomson has proved, by observations with his electrometer, that all the phenomena brought to light by atmospheric electricity, on a fine day, would be observed just as they are if the earth had a *negative* charge.

Lastly, in order to get a rough approximation of what sum be the difference of electric potential between inter-planetary space and the earth so that its own electric charge alone combined with its known rate of rotation round its axis shall produce the earth's magnetic moment, as determined by Gauss, Profs. Perry and Ayrton take as an example a solid sphere of iron of the size of the earth, and rotating with the earth's known rate of rotation, and they prove mathematically that something like a difference of potential a hundred million times the electromotive force of a single Daniell's cell would be sufficient for this purpose. They notice that there is no difficulty in imagining such a difference of potential to exist between the earth and inter-planetary space, seeing that there exists between the earth and the planets an enormous region of space having an insulation far higher than that of such a vacuum as experiment has shown will not allow the passage, from one point to another very near it, of a spark produced by a large induction coil.

Lastly, they draw attention to the fact that they have assumed the distribution of the electric charge on the earth's surface to be uniform, and so have arrived at a distribution of magnetic intensity dependent only on the latitude of the place, but that since it is possible that the sun and planets may have potentials differing immensely from that of the earth, it might be expected that the distribution of electric charge on the earth's surface, and consequently the magnetic intensity, would have variations like those of the tides, in fact such variations as are known to exist; also, that it would be anticipated that any sudden formation of vapour on the earth's surface, or alteration of the sun's atmosphere, or anything causing change in the lines of *static electric induction* from the sun to the earth ought to cause disturbances such as we know as magnetic storms. The alignments of planets with the sun and earth, again, or the proximity of planets to the sun having less than the average difference of electric potential from it, ought to diminish the disturbances

in the solar envelope and produce the alteration of sun-spots and terrestrial magnetism which is known to accompany such planetary motions. And, lastly, the authors point out that the known lagging of changes in terrestrial magnetism behind variations in the sun-spots would be explained if the great pressure to which the iron in the earth's interior is subjected produces, as is very probable, considerable coercitive force, for such coercitive force would necessarily cause changes in the magnetic intensity to lag behind the disturbances in the earth's electric charge produced by alterations in the static induction of the sun and planets.

V. THE JABLOCHKOFF CANDLE: ITS PRACTICAL RESULTS IN LONDON.

By CHARLES W. QUIN.

IT is now nearly three-quarters of a century since Davy first exhibited to an astonished and delighted audience, at the Royal Institution, a voltaic arc, of no less than 4 inches in length, playing between the terminals of the great 2000-plate battery with which he obtained illuminating and heating effects exceeding anything of the kind which had been heard of up to that time. For many years the most brilliant of terrestrial lights received no practical application, owing to its defects being numerous and apparently insurmountable. As to its adaptation to the wants of every-day life no really serious move was made in the right direction until within the last few years, up to which period it had only been used for lighthouses, building works carried on at night, a few factories, and some startling theatrical effects at the Paris and Vienna Operas, the efforts to apply it to street-lighting and other general purposes being sporadic and generally unsuccessful. Many of its original defects have long since disappeared, but much still remains to be done. The rapid waste of the charcoal terminals was obviated by Foucault in 1842 by the use of hard gas-retort carbon. The gradual weakening and ultimate cessation of the current, and the proportional diminution and final extinction of the light, were got rid of by the inventors of the different forms of constant batteries. The unequal wearing away of the two poles, and the consequent flickering and frequent extinction of the light, were almost entirely triumphed over in 1846 by Staite, who invented the first regulator or electric lamp. The enormous expense caused

by the rapid consumption of zinc in the battery was reduced to a minimum by the application of Faraday's great discoveries in magnetic electricity by Holmes, who made the first offer of his machine to the Brethren of the Trinity House in 1857, and their ultimate acceptance of it for lighthouse purposes on the recommendation of Faraday formed a new era in the history of the light.

The next important step in the development of the subject was the great increase of magneto-electric force obtained by means of the Siemens armature, in which the wire was wound longitudinally instead of transversely. Perhaps the most important step of all was the discovery—made apparently independently by Siemens, Wheatstone, and Varley—that the small amount of magnetic force contained in every bar of wrought-iron was capable, by action and reaction, of producing heating and lighting effects far superior to those obtained with artificial magnets. Another difficulty, the expense involved in having to provide a certain number of artificial magnets which were constantly losing strength, was now done away with, the cost of the current being thereby still further reduced.

In 1876 M. Denayrouze startled his colleagues of the French Academy by laying before them an invention of a young Russian officer which he designated an electric candle. Until then no one had thought of keeping the tips of the carbons always at the proper distance by placing them side by side. This was the most simple form of lamp yet invented; there was no clockwork to get out of order; there were no trains of wheels to stick when they ought to move; no delicate but capricious magnets; but simply a couple of brass sockets, with a double-stemmed candle, consisting of two rods of carbon separated by a seam of kaolin, thrust into them.

This is neither the place nor the time to inquire whether the Jablochkoff candle is better or worse than any other form of electric lamp. Be this as it may—and the truth can only be arrived at after long experience—the Jablochkoff candle was the means of bringing the question of electrical illumination before the world in a very prominent manner. It was first applied in Paris to the illumination of the showroom of the Magasins du Louvre and the adjoining courtyard, the Place and Avenue de l'Opéra, and the Hippodrome, thereby becoming the most prominent system of electric lighting known to the general public. From Paris its fame spread to London, and within the last three or four months its capabilities for public use have been put to the test in the metropolis in four different places—the Thames Em-

bankment, the Holborn Viaduct, the British Museum Reading-Room, and the fish-market at Billingsgate, under the able direction of M. Berly, the agent of the Paris Société Générale d'Electricité.

The experiment on the Thames Embankment is the most extensive and important that has yet been tried in England, both with respect to the number of lamps used and to the elaborate data which are being collected with regard to its cost, its virtues, and its defects. The portion of the Embankment which is lighted is that lying between Westminster and Waterloo Bridges, a distance of about three-quarters of a mile. The experiments have been carried out by the Metropolitan Board of Works under the direction of their engineer, Sir Joseph Bazalgette, and their consulting chemist, Mr. T. W. Keates, who have both determined that as far as in them lies the experiments shall be thoroughly exhaustive and their results conclusive. The engine and machinery for generating the currents are placed in a wooden shed on the west side of the Charing Cross railway-bridge, the conducting-wires being led under the roadway to the subway which runs under the footway next the parapet-wall of the Embankment, and so up to the lamps, which are carried by every alternate gas standard on the wall. The engine, which is by Ransome, Sims, and Head, is one of 20-horse power nominal, working at about 45 lbs. pressure. It is provided with a newly-invented governor, acting on the expansive principle, and has worked uninterruptedly from the 16th of December until the present time without a single hitch. It is to the extreme regularity of this engine and to the solid foundation which has been laid for it that we must attribute the great superiority in the steadiness of the Jablochkoff lights on the Embankment as compared with those shown elsewhere. The dynamo-electric apparatus consists of a Gramme continuous-current exciting machine and an alternate-current distributing machine of 20-light power. The number of lamps is twenty, divided into four circuits of five. They are, with one exception, supported by the gas standards on the river parapet, and, roughly speaking, are from 40 to 45 yards apart. From the engine-house to the farthest lamp on the Westminster side the distance is about 700 yards, and to that on the Waterloo side about 450 yards. Each lamp contains four candles, which are switched into their places as they are required by an automatic commutator, the holders being surrounded, with one exception, by opal glass globes 20 inches in diameter. Two lamps near the railway bridge are provided with flat reflectors, 4 feet in diameter, placed on the top of

the globe so as to throw the light downwards. One of these reflectors is turned inwards at an angle of 30 degrees for the space of 6 inches all round. The lamp under the bridge is provided with a very coarsely frosted globe, which shuts off much less light than the opal globes. Each candle lasts one hour and a half; the lamps therefore burn for six hours every evening.

The three months' trial ended on the 16th of March, but the Board of Works, determined that the experiments should be as complete and conclusive as possible, have renewed their contract with the Société Générale d'Electricité for an additional period of three months. It is rumoured that before long the whole of the Embankment from Westminster to Blackfriars will be illuminated by Jablochkoff candles. This could easily be done by providing an extra pair of dynamo-electric machines to work in the shed, the engine being at present worked at less than half its strength.

About the beauty and efficiency of the electric light, as applied to the illumination of the Embankment, there can be only one opinion, and that a most favourable one. The sternest opponent of the electric light, on account of its "weirdness," its "ghastliness," and so on, need only stand in the middle, and glance alternately at the Victoria and Albert Embankments, to be thoroughly converted, unless he be a gas engineer in what theologians call "a state of invincible ignorance." With men like Sir James Bazalgette and his colleagues controlling the results we may be sure of obtaining data that will be absolutely unprejudiced and indisputable, and their report will be awaited with impatience by all who take an interest in the great battle of the lights.

The City Commissioners of Sewers have acted very differently to their brethren of Spring Gardens, and have refused to carry on any more experiments in lighting the Holborn Viaduct, their engineer and surveyor, Colonel Haywood, having apparently frightened them by reporting that although the electric light was seven times as bright as gas, it was seven and a half times as dear. These city Solons would evidently like to buy diamonds at the price of paste, or shall we say real turtle at the price of mock? According to Colonel Haywood's Report, made on the 28th of February, to the Streets Committee of the City Commissioners of Sewers, arrangements were entered into in November last with the Société Générale d'Electricité for lighting the Viaduct from the western end of Newgate Street to Holborn Circus, with sixteen Jablochkoff candles, for a period of three months, beginning on the 14th of December.

Fifteen of the lamps were placed at alternate intervals on each side of the road, and one in the centre of the carriage-way at the junction of Newgate Street with the Viaduct. As in the case of the Embankment the existing lamp-posts were utilised, the gas lanterns being removed, and replaced by the Jablochkoff candles and their accompanying opal glass globes. Measured crosswise the distance between the electric lamps was about 110 feet, or about one-tenth farther apart than the electric lamps on the Embankment. The light from each lamp, according to Colonel Haywood, covered an area of 888 square yards of public way. The lamps were lighted at sunset and continued burning until midnight, and replaced eighty-six gas-lamps, sixty-one of which were lighted at midnight. The electric lamps were fed by two Gramme machines of a similar pattern to those used on the Embankment, driven by a Robey engine of 20-horse power nominal, the whole of the machinery being contained in a temporary shed erected on a piece of vacant land on the western side of Farringdon Street, close by the Viaduct. The lamps were arranged in four circuits of four each, and the conducting-wires were laid in tubes beneath the road and carried up inside the lamp-posts to the candles. The arrangement of the commutators was the same as on the Embankment.

With respect to the cost of the experiment, from the 14th of December to the 18th of February, the figures given by Colonel Haywood are as follows:—The Company agreed to provide, fix, and fit up the engine, machinery, conductors, and lamps for £236 8*s.* 4*d.*, and the Sewers Commission agreed to provide the shed and its enclosures and to do all the work underneath the roadway for about £267. From this must be deducted £50 10*s.* 10*d.* allowed by the Gas Company for gas not burnt. In case of sudden extinction—which happened on four different occasions—a lamplighter of the Gas Company was in constant attendance from sunset to midnight (an average of seven hours per night), at the comfortable wages of a few pence over £2 per week, which can hardly be considered exorbitant considering the onerous nature of his duties. The sixteen lamps were lighted from sunset to midnight at a charge of £5 per night, the average time which they have been alight during the experiment being (according to Colonel Haywood) about seven hours. The total cost of the experiment therefore, after deducting the saving in gas, cleaning the lamps used, &c., was £785 6*s.* 5*d.* The rest of Colonel Haywood's calculations we need not enter into minutely. He tells us that, at

£5 per light for the sixteen lamps, the cost per lamp is 10*s.* 7*d.* per hour, or about £3072 per annum for 4300 hours; the eighty-six gas-lights originally used costing during the same period £419, which is about two-fifteenths of the major sum. Colonel Haywood seems to have made no photometric experiments on the Viaduct light; his estimate that the sixteen electric lights give out about seven times more light than the eighty-six gas-burners is based on the observations of others. It will be seen from this that Colonel Haywood's data of the relative value of the two kinds of light are somewhat hazy; it would be interesting to compare his figures with those contained in the report of his *confrère*, M. Cernesson, Surveyor to the Paris Municipality, but the exigencies of space prevent it.

The lighting of the City thoroughfare was as successful in its way as that of the Embankment; the passage of the wayfarer from the yellow gloom of Newgate Street into the "sweetness and light" of the Viaduct was hardly more striking than his emergence out of the gentle moonlight of the Jablochkoff candles into the darkness visible of Holborn.

The third experiment was a highly successful one, and proved most satisfactorily that by employing a sufficient number of lights the British Museum Reading-Room might be made available to readers by night as well as by day. Fifteen out of the nineteen reading-desks were lighted by eleven candles, enclosed in an opal globe, and placed on a pedestal 15 feet high, fixed in the exact centre of each desk, a twelfth lamp being placed in the centre of the room: four of the desks were consecutively lighted, the remainder alternately. The reading-room was kept open until 7 o'clock on the evenings of the 3rd, 4th, and 5th of March, in order that the new light might be thoroughly tested in a practical manner by those for whose benefit the experiment had been made. The readers showed their hearty approval of the innovation by remaining behind in considerable numbers. On the first night a strange incident occurred. At a few minutes before 6 o'clock, when the twelve Jablochkoff candles suddenly flashed forth, the readers, led by a well-known poetess, and forgetting they were in the reading-room, evinced their admiration of the beauty of the light by a burst of applause—a sound hitherto unknown under that dome of silence.

Mr. E. A. Bond, the Principal Librarian of the British Museum, to whose initiative these experiments are due, has been at some trouble to collect information as to the opinion

of the readers, and there appears to be a general agreement that at the four desks each lighted with a candle it was perfectly possible to read, write, trace, draw, and even colour, with the greatest ease and comfort. The source of electricity on this occasion was a 20-light Robey portable engine of 16-horse power nominal. Four circuits of four lamps each were used,—that is to say, twelve in the reading-room, one in the entrance-hall, one in the portico, and two in the machine and engine shed. This experiment was remarkable for being the first occasion of the introduction of an improved Jablochkoff candle, in which the kaolin seam is replaced by a composition which is a feeble conductor. One of the great defects of the electric light, re-lighting by hand after sudden extinction from accidental causes, is thus entirely done away with. The use of carbon priming for lighting or re-lighting is no longer necessary, and one, two, three, or the whole of the four candles may be lighted or extinguished by turning the handle of a suitable commutator, or if one goes out it lights itself automatically without extinguishing its neighbours.

The Société Générale d'Electricité deserves great credit for the public spirit they have shown in gratuitously supplying everything necessary for making this interesting experiment, which will be carried into practice as soon as the consent of Parliament has been obtained.

The experiments at Billingsgate were a complete failure, from a somewhat ludicrous cause—the Jablochkoff candle was literally too good for the work it had to do. Business at Billingsgate, as most people know, begins between 3 and 4 in the morning, most of the bargains between the salesmen and their customers being struck by gaslight. If the beautiful goddesses and fairies of the stage that used to enthral our hearts in the days of our youth had been suddenly transferred from the yellow glow of the footlights into the open daylight the disenchantment would have been painful—Titania would have become converted into a Hecate, and Venus into a Megæra. The Billingsgate fish suffered a similar transformation under the searching rays of the electric light: soles that would have fetched a shilling a pair by gaslight looked dear at sixpence, while turbot fresh from the sea looked a week old. The result was a general outcry. The copious and ornate dialect of the locality was enriched by a number of notable additions during the few days that the electric light had sway; so, for fear of a revolt among the "bummarees," as the fish salesmen are called, the Corporation was obliged to restore

to them their beloved yellow gaslights, and, through no fault of its own, the Jablochkoff candle know the sons and daughters of King Belinus no more.

VI. THE TORNADO AT WISCONSIN IN 1878.

NEARLY five years ago* we gave as full a description as could be obtained of a tornado which occurred in Iowa and Illinois on May 22nd, 1873. Singularly enough a storm, accompanied by a tornado extending nearly across Wisconsin, which for extent and violence surpassed any storm previously recorded in the history of the State, swept over Iowa, Northern Illinois, and Southern Wisconsin only one day later of the same month in 1878. We are indebted to Prof. W. W. Daniells, of the University of Wisconsin, for a complete account of the tornado of May 23rd, 1878, and we regret that the space allotted to a single article in the "Monthly Journal of Science" will only permit of a very brief abstract of his description of its character and extent.

With regard to the origin of the storm it has been impossible to obtain data leading to any definite conclusion. At about six o'clock of the same day a tornado from a south-westerly direction struck the earth near Barrington, in the north line of Cook county, Ill., passing over Highland Park half an hour later. The same evening at half-past six a tornado occurred north-east of Quincy, Ill., in Adams and Brown counties. The occurrence of these several tornadoes, together with the fact that heavy rains fell throughout eastern Iowa, northern Illinois, and southern Wisconsin on that afternoon, shows that the Wisconsin tornado was not entirely the result of local conditions, but that some cause producing unusual atmospheric disturbance was widespread. The weather chart accompanying the Monthly Weather U.S. Signal Service indicates an area of low barometer for May 23 extending over the entire Lake region.

The evidence obtained by Prof. Daniells seems to prove conclusively that the tornado was a whirlwind of unusual

*See Quarterly Journal of Science, vol. v. (N.S.) p. 339.

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proportions, having its motion of revolution in a direction opposite to that of the sun, or from the east to the north, west south, to the east again.

According to the most reliable information as to the rate of the forward movement of the storm, it struck the earth at about 3 p.m., between which time and 5.30 p.m. it passed over a distance of sixty-four miles, which would be at the rate of twenty-six miles per hour. Any conclusions upon the velocity of the wind within the tornado can, as Prof. Daniells points out, only be reached by indirect methods. The wind's rotatory velocity south of the axis would be increased, while north of the axis it would be diminished by the progressive movement of the storm. The amount of increase or diminution would, however, differ greatly in different parts of the whirl. That the velocity of the motion of revolution increased from the outer edge toward the centre is shown by the fact that buildings near the centre were reduced to the dimensions of kindling wood in a way which never occurred near the borders of the track. Hence the horizontal velocity of each particular volume of air was continually changing as it occupied different positions relative to the axis and to the centre of the whirl. Again the wind had an upward motion, the perpendicular component of which acted upon bodies to hold them in suspension. The velocity of this upward motion also increased toward the centre of the whirls, and was comparatively slight near its limits. The actual velocity of the wind at any point would be the resultant of the horizontal and perpendicular velocities at that point.

The perpendicular velocity can be approximated by the lifting force exerted upon bodies while holding them in suspension. For instance, a horse weighing about 1100 lbs. was carried over twenty rods. Another of about the same weight was carried about eighty rods. A horse of this size would not expose a lifting surface to the wind of over 14 square feet. To lift such an animal would require then an upward pressure of the air of $\frac{1100}{14} = 78{\cdot}5$ lbs. per square foot. This pressure is produced by wind moving with a velocity of 124·6 miles per hour. In the township of Jefferson a granite boulder 15 in. square and more than 6 in. in thickness, and weighing more than 130 lbs., was carried 15 rods. To hold this rock in suspension would require a lifting force of 852 lbs. per square foot of surface. This force would be exerted by wind moving with an upward velocity of 129 miles per hour. These examples show the

great velocity with which the wind moves in such a storm.

There were three distinct storm paths west of Rome, Jefferson county, which is as far as Prof. Daniells's personal observations extend. It was, he remarks, impossible to trace any connection upon the surface of the earth between the different storms, although the ground between them was all passed over and most diligent enquiries made. The evidence gathered in regard to the time of occurrence of these different tornadoes shows conclusively not only that they were distinct but also that the second and third were contemporaneous with the eastern portion of the first one, and also that the three were dissipated very nearly at the same time.

The effects of these tornadoes as pourtrayed by Prof. Daniells was most disastrous. In the City of Mineral Point alone the amount of damage is estimated at 3,904,500 dols. The largest individual losses in this city were those of Mr. Gillman and Mr. John Spensley, respectively 20,000 dols. and 11,000 dols. The house of Mr. John Spensley, a large new frame house, with all its contents, was torn to fragments and swept away, some portions having been found a mile distant. Twelve persons were in the house, all but one of whom were in the cellar. Mrs. Waller, who remained to find a child she supposed had not gone to the basement, with the family, was instantly killed. No one in the cellar was injured. Mr. Spensley's barn and carriage house were completely demolished, and his carriages and sleighs broken past repairing, yet a horse standing in the farm escaped without injury. Another house belonging to Mr. Spensley, occupied by George Leonard, was destroyed, and Mrs. Leonard instantly killed. Seven other houses and five barns were utterly destroyed, and four houses and a large brewery unroofed and otherwise injured. Mrs. Myers and Mrs. Bohan were killed, as their respective residences were destroyed, and several others received injuries. Three horses and some other stock were killed within the city limits. Had the storm continued the course it was on, half a mile west of the city, it would have passed for three quarters of a mile over a part of the town very largely populated, in which case the loss of life would have been very great, and the suffering and destruction of property many times greater than it now is.

As the storm passed on its way a school house containing fifteen children and the teacher was destroyed, everything above the floor being carried away. The teacher was carried about 15 rods, but not materially injured. Two children

were killed, one injured, the remaining escaping without injury. The school record was found next day over sixty miles distant.

At about three quarters of a mile from the township of Waldwick the barn and blacksmith shop of Stephen Terrell were razed to the foundation. A waggon and threshing machine and many other farm implements were broken, a corn cultivator was carried twenty-five rods and completely demolished. Mr. Terrell's house, near the centre of the storm's path and in a very exposed position, was scarcely injured. Seeing the storm coming some distance across the prairie, Mr. Terrell hurried his family into an embankment cellar, remaining outside himself until it was but a short distance away. He described the cloud as reaching to the ground, the lower part so black and opaque that nothing could be seen within it, while at a height of 200 or 300 feet the air appeared to be filled with trees, rails, boards, hay, leaves, and other débris, all rapidly whirling, and shooting upward and downward in terrible commotion.

The storm passed into the township of Primrose. The house and outbuildings of M. Obermbt were swept away. The house was torn to pieces and scattered to the south and south-east. Mr. Obermbt and seven children were in the house at the time, and were thrown into the yard with the flying fragments of the house. One boy, fifteen years of age, was carried about fifteen rods nearly south into a ravine. Although the ground was so thickly strewn with the ruins as to be literally covered for 100 yards to the south and south-east, no one of these eight persons was seriously injured. The farm waggon before the storm stood six rods east of the house. After the storm it was in ruins twelve rods west of the house. Fifty rods south of Obermbt's, where a granary was being built, a waggon loaded with lumber was broken to pieces. One wheel was carried a quarter of a mile directly east, and another a mile and a quarter in the same direction.

Nearly half a mile east of Obermbt's the house and outbuildings of J. Osmonson were destroyed. Mr. Osmonson seeing that a severe storm was approaching, left the field where he was at work, that he might not get wet. Becoming somewhat alarmed at the roaring, the continuous lightning and thunder, and the very threatening aspect of the sky, he waited at the stable only long enough to unharness one horse, hurried into the house and told his wife they must hasten to the cellar. A boy of fourteen years and a girl of eight got into the cellar, and Mrs. O., with an infant

three months old, were partly down when the house was taken bodily. At this time Mr. Osmonson, with a child in each hand, aged respectively four and six, stood at the cellar door waiting for the mother and her babe to get fully down. Besides these, there was in the house a girl twelve years old. This girl was found thirty yards distant north of east, senseless, nearly buried in mud, with two severe scalp wounds, and her right arm broken, three times between the shoulder and elbow. About four rods north of the house was the border of a large field of second growth oak and poplar timber, from 20 to 40 feet in height. The house was carried over the timber, with Mr. Osmonson and the two children, whom he still held firmly in his grasp. While in the air over this timber the house "went to pieces," the larger portion of it falling sixteen rods directly north of its starting point. One portion of the roof was twenty-five rods distant in a direction north 30° west, and another portion sixty rods distant north 25° east. The stove was mainly found seven rods directly north of the principal ruins of the house; some parts, however, were carried several rods farther in the same direction.

Mr. Osmonson and the two children fell about 20 ft. north of the main ruins of the house. Mr. Osmonson had his face scratched and one rib broken in falling through the top of a tree. The children were entirely unhurt, the youngest one did not even cry. Large hail was falling at the time, and the children were laid under the ruins of the house while the father hastened to find the other members of the family. The children in the cellar were not hurt. Mrs. Osmanson was injured in the back, probably by something striking her as the house moved off. The stable in which the horses had been put was eight rods south-west of the house. One of the horses was blown into the cellar, and lay there upon his back when found, while the other was in the standing timber, twenty-two rods distant, north 38° east from the stable, with his hind feet resting upon the ground, while his fore feet were hanging upon a bent over sapling. The position of the horse, and the thick growth of timber rendered it impossible for him to get there only by being carried above the tops of the trees and dropped down. He was uninjured. An iron pump with 46 feet of zinc pipe was taken from a well, and carried north 15° west, a distance of fifteen rods. A lumber waggon was broken entirely to pieces. One wheel and an axle was carried north 65° east, seventy-five rods, while the larger proportion of the remainder went north-

east sixteen rods. One wheel was entirely broken to pieces and the tire left hanging on a tree 10 feet from the ground. This tire, ½ in. thick, 1 and 1½ ins. wide, and very slightly worn, was broken twice in two and bent in such a manner as to show that it had been acted upon by a force of great power.

Eighty rods north-east of Osmonson's stood a house belonging to Mrs. Ketchum. This house was on the south side of a hill. It was taken bodily from the foundation, up the hill north, and left in a little niche in the woods north-west from its starting point fifteen rods. The family escaped by going to the cellar.

The storm bent to the north at this point, destroying everything in its course, and scattering the débris east, west, north, and south. The deed of a farm, the house and two barns of which were destroyed, was found ten miles distant. A portion of an organ in the house was found 4½ miles directly north, while the boiler and some cooking utensils were carried east one mile. On the bank of Sugar river a granary and log house were destroyed. The stove, a part of the furniture, and some of the logs of the house were blown into the river. A lady school teacher boarding at the house was saved from the same fate by a log falling upon her and holding her down. And this work of destruction proceeded until in Jefferson county the storm entered an open marsh and was dissipated.

It has often been noticed that the severity and destructive violence of tornadoes is much greater in some portions of their path than in others. In the present case there are instances of buildings remaining uninjured while strong ones near by were destroyed. In many places where there was continuous timber there would be strips from ten to thirty rods long in a direction parallel to the axis of the storm, where nearly every tree was prostrated, then an interval where little damage was done, and again another piece where all were down. Tracts of interrupted violence frequently reached entirely across the track of the tornado, but they usually extended only partly across. In Prof. Daniells's opinion they were more frequent north of the axis than south.

VII. THE ELECTRIC LIGHT FOR INDIA.

IN the report on the results obtained by the electric light experiments, instituted on behalf of the Board of Directors of the East Indian Railway Company, Mr. Louis Schwendler states that in endeavouring to determine the quantity of light per unit of power, unit of speed, and unit of money, he tried four different dynamo-electric machines producing the electric current in *one* direction, viz., a medium and a small-sized Siemens (Hefner von Alteneck) dynamo-electric machines; a dynamo-electric machine, workshop pattern, as supplied by Messrs. Soutter and Lemonnier, of Paris; and a dynamo-electric machine with two sets of brushes, as supplied by the British Telegraph Manufactory. The trials have established that these four machines are all sufficiently practical for the production of the electric light, and that the unit of light as produced in the electric arc by any of the four dynamo-electric machines is at least fifty times cheaper than the unit of light as produced by combustion, considering the expenditure of power only. This represents an enormous engineering margin in favour of the electric light.

The Siemens medium dynamo-electric machine, however, gives about double the quantity of light of any of the other three machines, and only about half as much power is expended to produce the unit of light. This favourable result is principally due to the comparatively small internal resistance of the machine, and to its low speed.

For use in India Mr. Schwendler proposes several alterations in the machine.

With regard to lamps, Mr. Schwendler for practical use prefers the Serrin lamp, with the following alterations, which his own experiments have suggested:—

1. All parts of the lamp, including clockwork, &c., to be made of gun-metal. No steel or iron is to be used except in the electro-magnet and its armature.

2. The carbons may be of any shape—round, triangular, or square. The carbon-holders, constructed as in the Siemens lamp, should be sufficiently large to hold a round carbon of 18 m.m. diameter. With 18 m.m. carbons the lamp should burn eight hours.

3. The screw for regulating the tension of the spring or springs which act in opposition to the magnetism of the

electro-magnet should move 1 m.m. by one whole turn. In order to know the adjustment at any one time, and to be able to make the *same* adjustment again, a millimetre scale is to be attached, by which the movements of the screw can be read. The circumference of the head of the screw is to be divided into ten equal parts. Hence by this arrangement the comparative tensions of the spring or springs can be read up to 0·1 m.m. This micrometer screw, after the lamp has been regulated for any given current varying within two known limits, is to be fixed by a clamp and screw to keep that adjustment *constant.*

4. The distance between the electro-magnet and its armature is also to be made adjustable by a micrometer screw, provided again with millimetre scale like the above, and with a clamp and screw, for making any best adjustment *constant.*

5. The clockwork and all regulating parts of the lamp to be entirely covered by a strong metal case, which is to be constructed in such a manner that it can be taken off or put on without interfering in any way with the adjustment of the lamp. The case may be cylindrical, opening like a door in two halves on hinges, and with a key for closing it. None of the adjustable parts of the lamp are to protrude, as it is intended not to touch the lamp after its proper adjustment, which is done in the laboratory only. Each lamp has only *one* best adjustment for any given current varying between two known limits, and the best adjustment is made constant by fixing everything. The case or cover is then closed, and the lamp put up for use.

6. The electro-magnet which pulls the arc should offer no more resistance than 0·02 S.U. It is to be *shunted* by another electro-magnet which offers exactly the same resistance. Hence one-half of the current passes through the electro-magnet of the lamp, and is made use of *for pulling the arc.* The amount of iron used in the electro-magnet, and the number of convolutions, should be such that at the mean distance of the electro-magnet from its armature the magnetic force is strong enough to produce an arc of 2·5 m.m. against the mean tension of the spring or springs when employing a current of about 25 Webers. The magnetic action of the shunt for the same current should be about double that of the electro-magnet of the lamp, in order to leave a margin for a finer adjustment, *i.e.*, equalisation of the magnetic action of the two. The two electro-magnets, each forming a shunt to the other, are adjusted in such a manner that the extra currents they produce, when the

primary current varies, are equal, and therefore, as they are invariably opposite to each other, they neutralise one another entirely, which will have the desired effect of a quicker regulation of the lamp for any variation of current. The iron used in the shunt should have double the weight of the iron in the electro-magnet. The section of the wire for filling the shunt should be double the section of the wire filling the electro-magnet. Coil on so many convolutions on to the shunt until its resistance becomes equal to the resistance of the electro-magnet.

For adjusting the quality of the extra currents the following method should be adopted:—

Form a Wheatstone bridge two sides of which are formed by a mercury rheostat, each side offering about 0·02 S.U. resistance. The third side of the bridge is formed by the electro-magnet of the lamp, the fourth side by the shunt. In one diagonal place a dynamo-electric machine and about *one unit* resistance, together with a convenient make-and-break contact, best done by a mercury cup. In the other diagonal place a Bell telephone of lowest possible resistance. One end of this diagonal can be moved along the mercury rheostat. Start the dynamo-electric machine, listen to the telephone, and alter the ratio of the mercury branches of the bridge, by shifting along the contact until the telephone is perfectly silent. Then if, at commencing and stopping the current, a strong click is heard, we know it is due to the two extra currents not being equal, and as we further know that the shunt produces the greatest extra current we make this extra current smaller, by shifting along the two poles of the shunt an iron wedge, until the telephone is quiet when starting and stopping the current. The iron wedge is then fixed in its position. This shunt is also to be *inside* the metal cover of the lamp.

7. The two terminals of the lamp are to be of exactly the same pattern and size as those used in the dynamo-electric machine. They must *not* be terminals with hand-screws, but strong hexagonal-headed screws with lock-nuts.

The *division of the electric light—i.e.*, the production by the *same electro-motor* of a number of lights at different points of a given space—Mr. Schwendler considers to be impracticable from an engineering point of view. Such divisions of the electric light can, he argues, only be effected by a large sacrifice of total and external light, and moreover this loss increases rapidly with the number of lights burned in the same circuit. He succeeded in working three Serrin

lamps connected up successively in the circuit of a dynamo-electric machine, but found the loss of light very great. It appears that the electric light can alone compete with light produced by combustion when produced of great intensity in *one* point by *one* dynamo-electric machine.

Having satisfied himself of the difficulty and impracticability of the division of the electric light, he tried *diffusion*—*i.e.*, a few large lights (each light produced by one machine) are placed at different points of the space, and by optical means the light is diffused over a large area. This method is found to be perfectly practicable. There is naturally also a large amount of light lost (by absorption), but this loss will bear a constant ratio to the total light produced, and probably may decrease with the intensity. The light is diffused by means of a *silvered glass* reflector in which a powerful electric light burns, throwing *direct* and *reflected* rays up to a white ceiling, or any other convenient white surface. The form and size of each reflector must of course depend on the locality where it is to be used.

Mr. Schwendler recommends the employment of the electric light at railway-stations in India. The station is to be lighted up with four powerful electric lights, placed judiciously, so as to have the greatest and most uniform effect, each light being produced by *one* lamp and *one* dynamo-electric machine. Each light, by an opaque silvered glass reflector, is thrown against a white ceiling or any other white surface. No *direct* rays are allowed to enter the retina. This, Mr. Schwendler says, produces a light effect, resembling daylight, with no shade whatsoever. The intensity of the light will be such that the smallest print can be read by a normal eye at any place on the platform.

VIII. PAINLESS DEATH.

IN one of his lectures Prof Tyndall spoke of the probabilities in favour of the entire absence of pain accompanying death by lightning. It is popularly supposed that an impression made upon the nerves—a blow or puncture—is felt at the precise instant it is inflicted, but such is not the fact. The seat of sensation is the brain,

and intelligence of the injury must be transmitted to this organ through a certain set of nerves, acting as telegraph wires, before we become conscious of pain. This transmission or telegraphing from the seat of injury to the brain requires *time*, longer or shorter, according to the distance of the injured part from the brain, and according to the susceptibility of the particular nervous system operated upon.

Helmholtz, by experiments, determined the velocity of this nervous transmission in the frog to be a little over 85 feet per second; in the whale, about 100 feet per second; and in man, at an average of 200 feet per second. If, for instance, a whale 50 feet long were wounded in the tail, it would not be conscious of the injury till half a second after the wound had been inflicted. But this is not the only ingredient in the delay. It is believed that to every act of consciousness belongs a determinate molecular arrangement of the brain, so that, besides the interval of transmission, a still further time is necessary for the brain to put itself in order for its molecules to take up the motions or positions necessary to the completion of consciousness. Helmholtz considers that one-tenth of a second is required for this purpose. Thus, in the case of the whale, there is, first, half a second consumed in the transmission of the intelligence through the sensor nerves to the brain, about one-tenth of a second consumed by the brain in completing the arrangement necessary to consciousness, and, if the velocity of transmission from the brain to the motor nerves be the same as that through the sensor, about half a second more is consumed in sending the message to the tail to defend itself. Therefore one second and one-tenth would elapse before an impression made upon its caudal nerves could be responded to by a whale 50 feet long.

If we regard as correct the calculations representing the average velocity of transmission in the human nerves, and if we estimate the distance from the origin of the filaments in the brain to their termination in the foot as 5 feet, the time required, in case some one steps on your favourite corn, for the news to be telegraphed to the brain, for the brain to prepare a message, and to telegraph the same to the muscles of the leg to draw the foot away, would be about one-twentieth of a second. Now, it is quite conceivable that an injury might be inflicted which would render the nerves unfit to be conductors of sensation, and if this occurred, no matter how severe the injury might be, there would be no consciousness of it. Or it might happen that the power of the

brain to complete the molecular arrangement necessary to consciousness would be wholly suspended before there would be time for the transmission of the intelligence of the injury. In such a case, also, although the injury might be of a nature to cause death, this would occur without feeling of any kind. Death in this case would be simply the sudden negation of life, without any intervention of consciousness whatever.

Doubtless there are many kinds of death of this character: the passage of a rifle-bullet through the brain is a case in point. The time required for the bullet in full velocity to pass clean through a man's head may be roughly estimated at a thousandth part of a second. Here, therefore, would be no room for sensation, and death would be painless. But there is another action which far transcends in rapidity that of the rifle-ball. A flash of lightning cleaves a cloud, appearing and disappearing in less than a hundred-thousandth part of a second, and the velocity of electricity is such as would carry it in a single second of time over a distance almost equal to that which separates the earth and moon.

A luminous impression once made upon the retina endures for about one-sixth of a second, and this is why we see a ribbon of light when a glowing coal is caused to pass rapidly through the air. A body illuminated by an instantaneous flash continues to be seen for the sixth of a second after the flash has become extinct; and if the body thus illuminated be in motion, it appears at rest at the place where the flash falls upon it.

The colour-top is familiar to most of us. By this instrument a disk with differently coloured sectors is caused to rotate rapidly; the colours blend together, and, if they are chosen in the proper proportions, the disk will appear white when the motion is sufficiently rapid. Such a top rotating in a dark room and illuminated by an electric spark appears motionless, each distinct colour being clearly seen. Prof. Dove has found that an illumination by a flash of lightning produces the same effect. During a thunderstorm he put a colour-top in exceedingly rapid motion, and found that every flash revealed the top as a motionless object with its colours distinct. If illuminated solely by a flash of lightning, the motion of all bodies on the earth's surface would, according to Prof. Dove, appear suspended. A cannon-ball, for example, would appear to have its flight arrested, and would seem to hang motionless in space as long as the luminous

impression which revealed the ball remained upon the eye. If, then, a rifle-bullet passing through the brain move with sufficient rapidity to destroy life without the interposition of sensation, much more is a flash of lightning competent to produce this effect. We have well-authenticated cases of people being struck by lightning who, on recovery, had no recollection of pain.

The Rev. Dr. Bartol, who was lately nearly killed by lightning, expressed the belief that if the stroke proved fatal it must produce the most agreeable mode of death; but to be stunned, as he was, is very unpleasant. As soon as consciousness returned he experienced a terrible sense of oppression, and an irresistible weight seemed passing through him, while his mind was dazed so that for a while it seemed he had suddenly been precipitated into wonderland. His recovery was attended by headache, continued for a week.

The following case is described by Hemmer:—On June 30, 1788, a soldier in the neighbourhood of Mannheim, being overtaken by rain, stationed himself under a tree, beneath which a woman had previously taken shelter. He looked upward to see whether the branches were thick enough to shed the rain, and in doing so was struck by lightning, and fell senseless to the earth. The woman at his side experienced the shock in her foot, but was not struck down. Some hours afterward the man recovered, but remembered nothing about what had occurred, save the fact of his looking up at the branches. This was his last act of consciousness, and he passed into the unconscious condition without pain. The visible marks of a lightning stroke are usually insignificant, the hair being sometimes burnt, slight wounds occasioned, or a red streak marking the track of the electric discharge over the skin.

Prof. Tyndall relates—standing in the presence of an audience, about to lecture—that he accidentally touched a wire leading from a charged battery of fifteen large Leyden jars, and the current passed through his body. He says life was absolutely blotted out for a very sensible interval, without a trace of pain. In another second or so consciousness returned. He saw himself in the presence of the audience and in contact with the apparatus, and immediately realised that he had received the battery discharge. The *intellectual* consciousness of his position was restored with exceeding rapidity, but not so the *optical* consciousness. To prevent the audience being alarmed he stated that it had

often been his desire to receive, accidentally, such a shock, and that his wish had at length been gratified. But while making this explanation the appearance which his body presented to himself was that of being in separate pieces. His arms, for example, seemed to be detached from his body and suspended in the air. Memory and the power of reasoning and speech were complete long before the optic nerve recovered from the electric shock. The Professor dwelt upon the absolute painlessness of the shock, and believes there cannot be a doubt that to a person struck dead by lightning the passage from life to death occurs without consciousness. It is an abrupt stoppage of sensation, unaccompanied by a pang.—*National Medical Review.*

NOTICES OF BOOKS.

Notes by a Naturalist on the Challenger, *being an account of various Observations made during the Voyage of H.M.S.* Challenger *round the World, in the Years* 1872-76. By H. N. Moseley, F.R.S. London : Macmillan and Co.

We have here a general summary of the zoological and botanical results of the *Challenger's* vogage. It is remarked in the Preface that "very much of it was intended for family reading," and in fact no small portion of the book might—as far as internal evidence goes—have been written by any observant man of culture having no special acquaintance with any department of Natural History. We find even the music of the Tahitian National Air, a modern production which can scarcely be regarded as an ethnological document. It must further be remembered that, except as far as strictly Oceanic life is concerned, the circumstances of the Expedition were not too favourable to extended biological observation. The proportion of time spent on shore was not large, and, as the author declares, the zoological results of the deep-sea dredgings were disappointing. Hopes had been entertained, by the late Prof. Agassiz and others, that at great depths many important forms of old geological epochs would be found still existing. Such expectations have not been fulfilled; and though many new species, and even new genera, were obtained by the dredge, they belonged as a rule to well-known families, and very few displayed any important structural difference from forms already recognised. "We picked up no missing links to fill up the gaps in the great zoological family tree."

In another respect the results may be pronounced negative. Upon land wide areas have been found specially favourable to the production of variations and the development of new forms. Hence the faunæ and floræ of continents are relatively richer than those of islands. It might therefore have been expected that the ocean-floor, wider far than any continent and enjoying throughout conditions of temperature essentially alike, would have disclosed a corresponding exuberance of forms. The very contrary is the fact: deep-sea life is monotonous. Nor do the voyagers appear to have been favoured with a sight of any of the still unclassified monsters which the sea, according to some witnesses, may be supposed to contain. In *the* sea-serpent Mr. Moseley appears to be a decided unbeliever, and accepts the usual hypotheses of floating sea-weed, flocks of birds, &c., remarking further that "Sea-serpent stories are often utterly

without foundation in fact, and sometimes apparently ships from which they emanate are laden with rum."

On the subject of the visual powers and the colouration of deep-sea species we find some interesting remarks. The author very justly pronounces it quite conceivable that animals might exist to which obscure heat-rays might be visible, and to which men and other mammals would appear constantly luminous. On examining with the spectroscope the phosphorescent light emitted by three species of deep-sea Alcyonarians, he recognised the red, yellow, and green rays only. In connection with this fact it must be noted that "almost all the deep-sea shrimps and Schizopods are of an intense bright scarlet, differing markedly in their intensity of colouring from shallow-water forms, and having, apparently for some purpose, developed an unusually large quality (quantity ?) of the same red pigment which colours small surface Crustacea." Many deep-sea Holothurians are, however, dark purple, and in their case Mr. Moseley considers the colouring useless, and due merely to the persistence of a pigment developed originally in shallow-water ancestors.

Among the more important observations on fishes we may refer to the notice of *Periophthalmus Kolreuteri*, which travels on mud and moist earth, using its pectoral fins as saltatory legs. Concerning flying fish the author agrees with Dr. Möbius, that the species of *Exocœtus* do not flap their fins at all during their flight. As to the *Dactylopteri* (the flying gurnets) he has distinctly seen the fins or wings in rapid movement.

Among terrestrial animals Mr. Moseley appears to have paid the greatest attention to birds. He mentions that the Apteryx of New Zealand "considers it necessary to put as much of its head as it can under its rudiment of a wing, when it goes to sleep"—a very curious instance of the persistency of habits. On the other hand, we find a converse case where part of the penguins on the small island of Inaccessible have learnt to nest in holes under rocks, where the swine cannot get at them. On the north side of the island, where the pigs cannot get, the penguins retain their original mode of nesting on the open ground. The account of the voyagers making their way through a penguin colony is not pleasant reading.

Concerning insects we find fewer observations than might have been anticipated. Referring to a flock of a dozen males of *Ornithoptera poseidon* who were paying their court to a single female, the author proposes some experiments to test hypothesis of sexual selection, both in case of butterflies and birds. "A hen might be kept in a cage between two males, noting to which she gave the preference, and then whether any alteration in the colours of the plumage caused a change in her inclinations."

A starling (*Calornis metallica*) is mentioned as having been found caught in the web of a yellow spider at Little Ke Island, and at St. Thomas a large ground spider (*Lycosa*) is said to

habitually prey on lizards. At Juan Fernandez the author was struck with a showy flora, co-existing with a paucity of insects—an observation similar to that said to have been made in the mountains of Guiana by Schomburgk.

Whilst watching the movements of seals in the water, Mr. Moseley was struck by their close connection with the whales, and saw how easily a whale might be developed out of a seal. The fur-seals when on land still bend their hinder limbs forward, as do land mammals. The sea-elephants carry their hind legs always stretched backwards, when little modification is needed to turn these otherwise useless members into the broad tail-fin of the whale.

With reference to the interval between man and the anthropoid apes, we find an utterance with which we heartily agree :—"The wide, but unscientific, distinction commonly drawn between man and the higher monkeys is an error of high civilisation, and comparatively recent. To the Dyack, the great ape of Borneo is simply the Man of the Woods. The author, when at Tonga, was struck with the manner in which the natives, when conversing, incessantly contract and relax the muscles of the forehead and twitch up the eyebrows, just as do the monkeys.

Passing over abundance of other observations well worthy of notice, we come to a passage on the possible faunæ and floræ of other worlds. "On the theory of Evolution it is impossible that plants or animals, of any advanced complexity, at all resembling those existing on the earth, should exist on other planets or other solar systems. It is conceivable that very low forms of vegetable life may exist on other planets, and may have been by some means transported to the earth : the idea is conceivable, though highly improbable. But it is quite impossible that that infinitely complex series of circumstances which on the earth has conspired to produce from the lowest living forms a Crustacean should have occurred elsewhere ; still less is it possible that a bird or a mammal should exist elsewhere ; still more impossible that there should be elsewhere a monkey or a man. It is even probable that protoplasm itself, the basis of all life, is a production entirely confined to our small planet." To all this we must of course assent if—but only if—species are the result of an infinite number of fortuitous variations.

We cannot better convey our opinion of this work than by expressing the hope that the author may soon be engaged on some exploring expedition which may give him greater scope, and that we may have the pleasure of reading the account of his results.

A Monograph of the Silurian Fossils of the Girvan District, in Ayrshire, with Special Reference to those contained in the "Gray Collection." By H. ALLEYNE NICHOLSON, M.D., &c., and R. ETHERIDGE, Jun., F.G.S. (Fasc. I.—Rhizopoda, Actinozoa, Trilobita.) Edinburgh and London: W. Blackwood and Sons.

THE authors have been led to undertake a detailed and systematic description of the fossil remains found in the Silurian area of the Girvan district, which they consider will be an important contribution towards the solution of certain problems in both palæontology and geology. Judging from this first fasciculus they are carrying out their task with scrupulous care, accuracy, and thoroughness.

Studies in Comparative Anatomy. No. II. "Anatomy of the Indian Elephant. By L. C. MIALL, Professor of Biology in the Yorkshire College, and Curator of the Leeds Museum; and F. GREENWOOD, Curator to the Leeds School of Medicine. London: Macmillan and Co.

THE authors have dissected a young female elephant, and have been able to make not a few additions to and rectifications of the descriptions furnished by earlier observers. They have confined themselves almost exclusively to myology. The osteology and dentition they omit altogether, as ordinary text-books already contain descriptions sufficient for the purposes of the naturalist or the palæontologist.

Concerning the alimentary canal and its appendages, and the circulatory, respiratory, and reproductive systems, they give merely a summary of what is already known, supplemented by their own observations.

As regards the nervous system they are unable to give any novel information, the rather as the brain of their subject was not removed till eight months after death, when it was found too much disintegrated for examination.

They recommend those who may have the opportunity to make a microscopical examination of the large intestine of the elephant immediately while fresh, and also to investigate the brain minutely immediately after death. The value of this monograph is increased by the bibliography of the subject.

CORRESPONDENCE.

THE SEA-SERPENT.

To the Editor of the Monthly Journal of Science.

SIR,—With reference to the letter of "Serpent-Hunter," in your February No., I would beg to ask whether anyone has taken the taken the trouble to ascertain whether any such narrative as that quoted in Dr. Wilson's work was really deposed to at Liverpool, or whether the whole is not the invention of some audacious *canard*-monger? A friend tells me that this point has been raised by one of your contemporaries.—I am, &c.,

SCEPTIC.

SPIDER'S WEB FOR MICROMETERS.

To the Editor of the Monthly Journal of Science.

SIR,—Mr. W. Mattieu Williams, in his article on "Spider's Web for Micrometers," contained in your last issue, speaks of spiders as "his six-legged friends." This is doubtless a clerical error, as spiders have eight legs.—I am, &c.,

AN ENTOMOLOGIST.

ADHÉMAR'S THEORY OF EVOLUTION.

To the Editor of the Monthly Journal of Science.

SIR,—Has the possible bearing of Adhémar's theory upon the question of Evolution ever been thoroughly discussed? If every ten thousand years the waters of the globe are translated from the Northern to the Southern Hemisphere, deluging the continents on their way, must not the great majority of animal and vegetable species, terrestrial at least, be extirpated? If prior to the last of these great cataclysms the bulk of the water occupied the Northern Hemisphere, where were the wide continents in which the majority of organic species seem to have taken their rise?

I am well aware that Adhémar's theory is far from being demonstrated; but is not its doubtful compatibility with the doctrine of Descent at least worthy of consideration? If the Antarctic ice-cap possesses the dimensions lately ascribed to it in the "Quarterly Journal of Science,"—say a thickness rising from about half a mile at its margin to 24 miles at its centre, and extending over a circle of 3000 miles diameter,—it seems to me that we have here a mass of water which if rapidly set at liberty would go far to render Adhémar's deluges (with the last of which that of Noah is probably identical) at least physically possible.—I am, &c.,

A. P. P.

THE SENSES OF THE LOWER ANIMALS.

To the Editor of the Monthly Journal of Science.

SIR,—In an article on the "Senses of the Lower Animals," inserted in your last year's volume, the alleged fondness of serpents for milk and their power of destroying it by smell are incidentally referred to. In "Science Gossip" a case is mentioned, on the authority of a country clergyman, where a viper followed for some distance a woman who was suckling her infant. Popular tradition in many parts of Europe accuses snakes of fastening on the teats of cows. Now I do not deny that serpents may have an acute scent, as the manner in which the common viper congregates wherever the marsh-rosemary (*Ledum palustre*) flourishes seems to be sufficient affirmative evidence; but in my own somewhat extensive personal experience I never met with any instance of a snake of any kind being attracted by milk, and I should be happy to hear if any of your naturalist readers have in this respect been more successful.—I am, &c.,

SERPENT-HUNTER.

OPTICAL ILLUSIONS—A CORRECTION.

To the Editor of the Monthly Journal of Science.

SIR,—On page 236 of the March number of your Journal a footnote to my article on "Optical Illusions" states that "An account of a very similar observation was communicated by Mr. J. Aitken to the Royal Society of Edinburgh, in November, 1878, apparently without any knowledge of the observations of Addams, Brewster, or of the author of this article." I have received word from my friend Mr. Aitken that, while the observation was

made without any such previous knowledge, references to the older observations were given in the account communicated to the Royal Society of Edinburgh, and Mr. Aitken has courteously permitted me to peruse his paper in confirmation of the fact. I will only add that no mention of previous workers appeared in the abstracts given by the scientific press which came under my notice; and the inference that Mr. Aitken was not aware of the existence of these when his paper was presented to the Society appeared to be confirmed by the title he gave it, describing the phenomenon as "A *New* Variety of Ocular Spectra."

I am happy, however, to make the correction which Mr. Aitken has pointed out to me.—I am, &c.,

S. P. Thompson.

University College, Bristol,
March 13, 1879.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY, *February* 13.—A paper by Mr. J. E. H. Gordon, "On an Extension of the Phenomena discovered by Dr. Kerr, and described by him under the title of 'A New Relation between Electricity and Light,'" was read. In November, 1875, Dr. Kerr announced, in the "Philosophical Magazine," that he had discovered a new relation between electricity and light. He showed that when glass is subjected to an intense electrostatic stress that a strain is produced which causes the glass to act like a crystal upon polarised light. While the author was endeavouring, by means of the electric light, to project the effect of Dr. Kerr's experiment on a screen, the electrostatic stress was accidentally allowed to become strong enough to perforate the glass. Immediately before perforation there occurred the following effects:—First appeared a patch of orange-brown light, about 6 or 7 inches diameter. This at once resolved itself into a series of four or five irregular concentric rings, dark and orange-brown, the outer one perhaps being 14 inches diameter. In about two seconds more these vanished, and were succeeded by a huge black cross about 3 feet across, seen on a faintly luminous ground. The arms of the cross were along the planes of polarisation, and therefore were at 45° to the line of stress. The glass then gave way, and all the phenomena disappeared except the extreme ends of the cross, and the discharge through the hole, where the glass had been perforated, was alone seen.

February 27.—"Studies in Acoustics. I. On the Synthetic Examination of Vowel Sounds." By William Henry Preece and Augustus Stroh. In their investigation the authors assumed that vowels are compounded of a prime sound and certain upper partials. Since each partial can be considered as a simple harmonic curve, if we assume the pitch of a prime to be constant, then it would be possible, by means of a machine, to represent and vary each partial in phase and in amplitude. For this purpose an instrument was constructed, which the authors call "the synthetic curve machine," in which a number of toothed wheels are mounted on steel pins or axes rigidly fixed on a board, so that they will revolve together, and the numbers of their teeth are so calculated that during one revolution of the wheel A, B will make two, C three, D four, E five, F six, G seven, H eight revolutions, and so on. Besides assuming the pitch to be constant, the authors assumed that each octave of the partial, to

maintain equal loudness of sound, must diminish one-half in amplitude as it rises. This instrument enabled the authors to form synthetically all the curves produced by vowel tones, and to show how these tones are compounded of primes and harmonic upper partials. It shows how *simple tones* can be produced by simple harmonic curves, and *compound tones* by the simultaneous action of several simple tones. The authors then determined to try to reproduce the vowels by sounding a prime and one of its partials alone. This was done by means of an electro-magnet vibrating an armature with a movable spring attached to it in such a way that the vibrations of the armature could produce a given prime, while the vibrations of the spring, by varying its length, could also be adjusted to any particular partial. The effect not being by any means perfect, a machine was made on the principle of the synthetic curve machine, which would, instead of drawing curves on paper, reproduce eight partials by transferring the vibrations of the intermediate wheels to a vibrating diaphragm. Here, again, though the vowels were fairly reproduced, something was wanting in their clearness. Another machine was now made upon which disks were fitted, whose peripheries were cut in exact copy of the curve produced by the synthetic curve machine. These curves were transmitted by vibration to the receiving diaphragm of a phonograph, and really formed an "automatic phonograph." With this instrument the sounds most resembling the vowel sounds of the human voice were easily recognised. But although the reproduction of vowels was good, it was imperfect, and it follows from this investigation, as far as it has gone, that vowels cannot be reproduced exactly by mechanical means. Something is always missing—probably the noises due to the rush of air through the teeth, and against the tongue and lips. One very curious result arising from the experiments with the automatic phonograph was to show that, by varying the pitch, the vowel sounds could be shifted,—*i.e.*, the curve which produced *oo* at a low velocity becomes approximately at *O* a higher velocity. *O* similarly becomes *ah*, *ah* becomes *a*, and *a*, *ee*. The curves arrived at synthetically do not differ very materially from those arrived at analytically by Helmholtz; they principally differ in the prominence of the prime. But curves produced by the synthetic machine, compounded of the different partials without their prime, show that there exist *beats* or resultant sounds. A vowel sound of the pitch of the prime may be produced by certain partials alone, without sounding the prime at all. The beat in fact becomes the prime. This point is clearly illustrated, orally, by the automatic phonograph, and graphically by the sketch drawn by the synthetic curve machine. The authors are investigating the true theory of the loudness of sound. They think that loudness does not depend upon amplitude of vibration only, but also upon the quantity of air put into vibration; and, therefore, there exists an absolutely physical unit

in acoustics analogous to the unit of quantity of electricity or quantity of heat, and which may be called the quantity of sound. In commencing their research the authors endeavoured to find a disk for the phonograph and telephone which would vibrate to the finest shades of sonorous vibration. They obtained the best results from a stretched membrane of thin india-rubber, rendered rigid by a cone of paper.

March 6.—"Preliminary Report upon the Comatulæ of the *Challenger* Expedition," by P. Herbert Carpenter, M.A., Assistant Master at Eton College. The collection of *Comatulæ* made by the staff of the *Challenger* includes specimens from forty-five different localities, but few of which are deep-water stations. *Comatulæ* were only obtained seven times from depths exceeding 1000 fathoms. At lesser depths, 200 to 1000 fathoms, *Comatulæ* were met with at thirteen stations; but by far the greatest number, both of species and of individuals, were dredged at depths much less than 200 fathoms, and often less than 20 fathoms, at twenty-six widely-distant stations. At the present time the author regards the collection as containing 111 species, mostly new; but as the work of examination and description progresses it is not unlikely that forms which he now considers different may turn out to be merely local varieties of one and the same species, so that the number given above may be subject to alteration. Of these 111 species, 59 belong to the genus *Antedon*, 48 to *Actinometra*, 1 to *Ophiocrinus*, and 3, which are peculiar in having ten rays to the calyx instead of only five, to a new genus, for which he proposes the name *Promachocrinus* (Greek *Promachos*, "Challenger"). In two of the species the rays are undivided, as in *Ophiocrinus;* but in the third they divide, as in our common *Antedon rosacea*, so that there are twenty arms. The voyage of the *Challenger* has, according to the author, settled two curious questions in connexion with the Crinoids, the origin of which is due to Lovèn. They refer to *Hyponome Sarsii*, a so-called recent Cystid, and to *Phanogenia*, a supposed new genus of the Comatulidæ. *Hyponome* turns out to be nothing more than the disk of a *Comatula*, minus its skeleton. The stellate condition of the centrodorsal in *Phanogenia* has long been a puzzle to the author, but the material brought home throws a considerable light upon it. This condition appears to be one of the concluding stages of a long series of changes in the shape and relations of the centrodorsal, which do not commence until some time after the loss of the stem, and the entry upon the free state of existence. The dredgings in Torres Straits brought up a considerable number of specimens of a hitherto undescribed *Comatula*. The author proposes to name it *Actinometra Jukesii*. The examination of the *Challenger* Comatulæ has entirely confirmed the opinions held by Dr. Lütken and the author respecting the distinguishing characters of *Antedon* and

Actinometra. They both agree in referring forms with a (sub) central mouth, five equal ambulacra, and no terminal comb on the oral pinnules, to *Antedon*. On the other hand, species with an eccentric mouth, a variable number of unequal ambulacra, and a terminal comb to the oral pinnules, belong to *Actinometra*.

CHEMICAL SOCIETY, *February* 6. — Dr. J. H. Gladstone, F.R.S., President, in the chair.

Dr. Frankland opened a discussion on a paper read by Dr. C. M. Tidy on December 6th, 1878, "On the Processes for Determining the Organic Purity of Potable Waters." In the course of a long address Dr. Frankland said that he entirely dissented from Dr. Tidy's suggestion that non-volatile matter may be removed *mechanically* during evaporation. He had proved by actual experiments that mechanical removal only took place during violent agitation or the breaking of gas bubbles at the surface of the liquid. He was still more astonished, however, to find Dr. Tidy, who is a physician as well as a chemist, suggesting that the poisonous constituents of sewage may be volatile. All the knowledge we have hitherto acquired about the infectious matter of epidemic disease pointed, he said, to the inevitable conclusion that the propagating material is not merely organic, but organised; and that its virulence, unlike that of arsenic or other similar poisons, resides in its vitality and its power of multiplying itself almost indefinitely in the human body. An organised liquid, gas, or vapour, was a physical impossibility, and hence there is no foundation whatever for the opinion that the poison of sewage is volatile, or that it is not contained in the residue left on evaporation. With regard to the albuminoid ammonia process, Dr. Frankland's experience coincided with that of Dr. Tidy. It had been put forward as capable of answering the question, "Is the water wholesome or is it not?" It did not, however, answer this question: It condemned water containing only peaty matter, and it acquitted water containing urea and uric acid? Could anybody believe that in 1876 the Chelsea Company's water, drawn from the Thames, was "safe" in January, "dirty" in March and August, "safe" again in November, and "of extraordinary purity" in December, when it contained no less than 0·423 part of organic elements in 100,000 parts of water; and when three other samples drawn from the same source were denounced as "dirty" by the same process. Again in 1871, whilst the West Middlesex Company's water was "of extraordinary purity" in January, April, and May, the Chelsea Company's water was "dirty" in those months, although quite "safe" in December. Floods undoubtedly make Thames water dirty, but the albuminoid ammonia curve pursued the even tenor of its way quite regardless of them. Dr. Frankland cordially agreed with Dr. Tidy's strictures on superficial and rapid analyses of waters, in which

the determinations were chosen with far greater regard to the analyst's time than to the needs of the inquiry. The so-called partial analyses were often very partial, and often brought disgrace upon the profession of chemistry. In conclusion, he congratulated the author on his valuable addition to the literature of water analysis, and on the clearness with which he had brought a great array of facts before the Society. His comparative tables were of great value, and he trusted they would be carefully studied by all chemists who practise water analysis. They formed a chart upon which the rocks so fatal to many a water analysis were so clearly shown that he who runs might read.

Mr. Wanklyn said that as long ago as 1867 Chapman, Smith, and himself directed attention to the cardinal defect of the combustion process, and this defect had never been overcome. It was this, that the organic matter in the water does not survive the evaporation to dryness. Dr. Frankland said that he would be content if he had a process to burn up the organic matter in the water itself. Messrs. Cooper and Wanklyn had invented such a process, and had burned up substances in solution.

Dr. Voelcker said that an impartial observer would come to the conclusion that all methods were more or less defective, and some gave very erroneous results. He would most earnestly urge the importance of determining all the constituents of a water, organic and inorganic, and not founding an opinion on one factor.

In his reply Prof. Tidy said he had concluded that the poison in water was volatile from analogy, because when it did act it was very virulent, and virulency and volatility usually go together.

EDINBURGH UNIVERSITY CHEMICAL SOCIETY, *January* 29.—Alexander Macfarlane, D.Sc., F.R.S.E., in the chair.

A paper was read by Mr. J. S. Thomson, "On Paraffin and what is got from it, as illustrated by 'Exhibits at the Paris Exhibition of 1878.'" A full account was given of the modes of preparation of these exhibits, which consisted of specimens of all the commercial products of the Addiewell Chemical Works. These included naphtha, burning oils, lubricating oils, solid paraffin in blocks (weighing not less than 7 cwts. each), sulphate of ammonia, and candles of various kinds made from the paraffin wax. The methods of preparation of other products of paraffin were also explained.

PHYSICAL SOCIETY, *February* 22, 1879.—Prof. W. G. Adams, President, in the chair.

Dr. Schuster gave the results of some observations made by a spectroscope with two prisms, one for the red and the other for the blue end of the spectrum, on the Spectrum of Lightning. Three observations were made, one at Las Ammas, one at Manitou, and one at Salt Lake City, last year. These showed the

three nitrogen lines, with three well-defined bands and one doubtful band. The nitrogen lines correspond to the spectrum of air, and the bands appear to Dr. Schuster to agree with the spectrum of the light round the negative pole of the spark in a tube containing oxygen with adulteration of carbonic oxide.

Prof. Ayrton exhibited an Exisothermal Model of a Cooling Globe. If we imagine a globe initially heated throughout to a uniform temperature (as was probably the earth), and then kept in a space having a constant temperature, but much lower than that to which the globe was heated, then the temperature at every point of the ball will fall, but at very different rates; the parts, for example, near the surface cooling comparatively rapidly, while those near the centre will cool very slowly. A surface could, therefore, be constructed, such that the x of any point on this surface represented its distance from the centre of the globe, the y the time t from the commencement of the cooling, and the z the temperature of that point at that moment. The nature of this surface would depend on the size of the globe, on the specific heat, conductivity, and surface emissivity of the material. The "Experiments on the Heat Conductivity in Stone" of Profs. Ayrton and Perry, described in the "Philosophical Magazine" for April, 1878, enables them to determine these constants accurately for a trachyte sphere, and by using these data they have been enabled subsequently to construct such a surface, called by them an "exisothermal" one for a trachyte globe of 8000 miles in diameter, and which gives graphically the temperature of every single point of the earth from the moment when it was at the temperature of molten trachyte down to eight hundred thousand million years afterwards,—that is, until long after the present era.

March 8.—Prof. Ayrton brought forward a new theory of terrestrial magnetism, originated by himself and Prof. Perry, of the Imperial Engineering College, Japan. (See p. 287.)

Mr. F. D. Brown described his apparatus for maintaining constant temperatures and pressures. A constant temperature can be obtained if the pressure can be kept constant. The vessel in which the constant pressure is desired communicates with an air-pump by a pipe in which a movable tap or valve is placed. By opening or closing this tap the pressure is regulated. This is effected by an electric clutch arrangement. A mercury anemometer sends a positive or negative current from a battery through the clutch according as the pressure is too high or low, and this current actuates the clutch to close or open the valve. The clutch consists of an axle driven by a turbine to get power to work the valve, and the current, by means of electro-magnetism, connects the tap to the axle, which then opens or closes it as the case may be. In this way a pressure varying no more than one-fifth millimetre each way can be obtained.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, *February* 18.—J. P. Joule, D.C.L., LL.D., F.R.S., &c., President, in the chair.

Professor Roscoe, LL.D., F.R.S., communicated a paper by Sadamu Ishimatsu, "On a Chemical Investigation of Japanese Lacquer, or 'Urushi.'" During a few months last year the author had the opportunity of examining roughly into the nature of "Urushi," in the Laboratory of Tokio University. The specimen of lacquer which he had under his examination was obtained from Kuyemon Nakamuraya, in Tokio, a large lacquer merchant. It is a milky juice of pale grey colour, and gives out a certain kind of poisonous volatile gas. Some persons are terribly attacked by this poison, producing a great swelling where the acid comes in contact. During the author's examination in the laboratory one of the apparatus keepers was terribly attacked by this gas, producing ugly swellings all over the face. By using the solution of chloride of sodium, carbonate of soda, acetate of lead, &c., he was said to have recovered within a week. This poison, however, acts only on certain persons, for the author while working with it never felt any uneasiness from it. The blackening of lacquer in air is by many supposed to be due to the combined action of light and air, but from the following experiments this seems to be erroneous:—1. A square box was made which had a well-fitting sliding door, and the inside of which was made perfectly black, so that practically no light was permitted to enter. In it was placed a small quantity of lacquer at dark, and the door closely shut. On looking at it the next morning it was observed that the lacquer had turned perfectly black, proving that it is not light that blackens the lacquer. 2. The bottle in which the specimen of lacquer was kept for more than three months was exposed to the incident light of the laboratory. The surface of the lacquer was turned perfectly black, forming a wall as it were; while those portions which were in contact with the sides of the bottle, which receive as much light as if there were not any glass sides before it, were not at all blackened. This phenomenon proves that the blackening in the atmosphere is in all probability due to the oxygen of the air, but not to light alone, nor to the combined action of light and air. The examination showed that the "Urushi" consists of three principal constituents: (1) a resinous part soluble in alcohol, (2) gum, and (3) residue. The resinous part soluble in alcohol seems to be the principal portion: it has a smell like ordinary lacquer, but it never dries as the original does. It is brownish black, and slightly sticky to the touch. When treated with potash solution it forms a bluish black precipitate, but nothing is obtained on addition of sulphuric acid to the filtrate. When boiled with hydrochloric acid the resin is transformed into a substance elastic while hot, something like the mass obtained when heated sulphur is dropped into cold water. When boiled with

nitric acid nitrous fumes are given out, and the mass gradually becomes yellow, and finally a beautiful orange-coloured mass was obtained. The mass was to a great extent soluble in absolute alcohol, leaving behind a small quantity of a yellowish body. A quantity of alcoholic extract was precipitated with acetate of lead, the precipitate was thoroughly washed with absolute alcohol, aad then decomposed by means of dilute sulphuric acid. The mass was dissolved again in absolute alcohol, then separated from sulphate of lead. This separated alcoholic extract was again precipitated by sugar of lead, and, after filtering and washing, the precipitate was dried partially in an air-bath, and carried under the receiver of an air-pump and dried over sulphuric acid. This lead salt exploded when heated. The amount of lead was estimated as oxide by igniting it with nitric acid, and the salt was subjected to organic combustion. Nitrogen was determined by Dumas's method. The following numbers were obtained as the mean results:—

Carbon	26·93
Hydrogen	4·11
NO_2	18·44
PbO	47·42
Oxygen	3·10
	100·00

The author then took alcoholic extract of the original lacquer and precipitated it with acetate of lead. After requisite purification and drying the precipitate, it was analysed, the lead being determined as before. The following is the mean of two experiments which were tried:—

Carbon	50·450
Hydrogen	5·705
PbO	3·775
Oxygen	40·070
	100·000

The gum is soluble in cold as well as in warm water. It has no smell, almost no taste; it has a yellowish, or rather brownish, colour, and is of a non-crystalline body. It is quite insoluble in alcohol. On subjecting this substance to organic analysis the following percentage of hydrogen, carbon, and oxygen was obtained:—

Carbon	41·20	41·45
Hydrogen	6·51	6·58
Oxygen	52·29	51·97
	100·00	100·00

These analyses yield a formula approximating to the composition of common gum. The residue is, the author thinks, nothing more than the mixture of cellulose, bark, dust, &c.

NOTES.

Agriculture.

From a paper by A. Johnen, in "Biedermann's Central-blatt" for January, 1879, "On Comparative Observations of Rainfall according to Fautrat's Method," we learn that the quantity of rain in a beech-wood is 13 per cent greater than in the open country. In a pine-wood the excess was only 2 per cent.

From manure experiments on the Agricultural Trial-field of the University of Giessen, Prof. A. Thaer finds that the quantity of nitrogen given to a selected "morgen" of land in the form of manures during seven years amounted to 89·5 lbs. The crops reared during the same years contained together 198·69 lbs. of nitrogen. Consequently the soil had given 109·19 lbs. nitrogen more than it had received. Hence, while the manures furnished 45 per cent of the nitrogen in the crops, the atmosphere had yielded 55 per cent.

According to Dr. E. Wein, Prof. J. Nessler, Prof. A. Mayer, and Prof. R. Heinrichs, the composition of an English cattle food is—

	Wein.	Nessler.	Mayer.
Moisture	13·72	—	12·9
Albuminoids	11·75	13·21	9·4
Oily matter	4·28	4·24	3·6
Non-azotised extractive	67·24	—	66·9
Vegetable fibre ...		—	3·6
Ash	3·01	—	3·6

Wein and Mayer, from chemical and microscopical evidence, conclude that the food is composed of equal parts of bruised maize and locust-beans, and that the essential oil of a plant of the umbelliferous order has been added. Another English cattle food in the form of cake contained also a large proportion of locust-beans.

Biology.

Mr. H. W. Bates, in his Presidential Address to the Entomological Society, refers to some unexpected facts in the geographical distribution of insects. Thus the insect fauna of New Zealand is quite distinct from that of Australia, and its origin will therefore have to be accounted for by a totally distinct set of causes. The Carabidæ of Australia have often a near but very peculiar relationship to forms of the same family in the Palæarctic region. Next to that great region, indeed, Australia is the richest part of the world in species and genera of the

Feronia group—a circumstance which ten years ago would have been deemed most unlikely.

Mr. J. W. Slater, writing in the "Entomologist," shows that the larvæ of gnats, midges, &c., instead of being sanitary agents, intensify the putrefaction of organic refuse suspended in water.

At a recent meeting of the Biological Society of Paris, M. Bert described the results of his experiments on the temperature of the brain. In a state of absolute inaction, bodily and mental, the temperature of both sides of the head is equal; but as soon as any brain-work is undertaken, if the equality does not continue, the left side always shows the higher temperature. According to M. Raymond, in cases of paralysis the temperature is higher in the parietal region than over the rest of the cranium; and here, again, the left side is found hotter than the right by 0·3 to 0·4 of a degree C.

At another meeting of this Society (March 1st) Dr. P. Bert described experiments made to elucidate the influence of the cerebral hemispheres upon the capillary circulation. One hemisphere of the brain of two axolots, a black and an albino respectively, and also of a bat, was removed. No modification of the capillary circulation resulted. There was produced, however, a bilateral paralysis of the chromotaphores of the skin, and the animal lost the power of changing its colour under the influence of emotions.

At a meeting of the Bordeaux Société des Sciences Physiques et Naturelles, Dr. Azam gave an account of an interesting case of double consciousness and scission of personality which has been under his observation for many years, and which has been described in the "Comptes Rendus de l'Academie des Sciences Morales." The patient, Felida X——, has, as it were, two distinct lives, two conditions separated from each other by a short sleep or a torpor of a few seconds. After her return to the normal state she is entirely unconscious of what has taken place during the abnormal condition, whatever its duration. She is more cheerful during this abnormal state than in the normal condition. When in the abnormal state she remembers, however, anything which has happened in her normal intervals. The author, in accordance with M. de Quatrefages, considers that the mnemonic cellules are disseminated throughout the brain. He formerly thought that they were seated in the right hemisphere, because the faculty of articulate speech, which resides in the left hemisphere, is never affected in Felida. This opinion is difficult to maintain, since the faculty of articulate speech cannot act without memory.

From a paper read before the Shanghai branch of the Royal Asiatic Society, by M. A. A. Fauvel, it appears that a true alligator—as distinct from the crocodile—has been found in China. Hitherto the alligator has been supposed peculiar to the Western

Hemisphere. The name proposed for the species is *Alligator Sinensis*.

Dr. A. Voisin finds that the brains of idiots are structurally little developed, remaining in a fœtal condition, or at most in a state like that of early childhood. The convolutions are abnormally simple, and present only a few nucleoli.

Mr. W. H. Edwards, in the "Canadian Entomologist," records the singular fact that ants cherish the caterpillar of *Lycæna pseudargiolus* (a small butterfly closely resembling the "blues" of English collectors), for the sake of a clear, green fluid, doubtless of a saccharine nature, which exudes from a peculiar mamilloid organ on the back of the eleventh segment, The most perfect understanding seems to prevail between the ants and the caterpillars, which must thus rank with the *Aphides* among the domestic cattle kept by our six-footed rivals.

Chemistry and Technology.

In a note on large crystal growing Mr. C. W. Quin remarks that a great difficulty is to guard against sudden rises in temperature, which generally have the effect of causing the growing crystal to be partially and unevenly re-dissolved. To receive a continually even temperature, after many experiments he hit upon the plan of plunging the beaker containing the growing crystal into the house-cistern, the temperature of the water in which never differed by more than 0·5° F. either way day or night. To prevent the solution from becoming exhausted too rapidly he immersed in it to the depth of half an inch or so a crystal drainer containing a filter-paper full of the salt to be crystallised, so that a constant stream of strong solution was continually descending on the growing crystal.

The double staining of vegetable tissues, various processes for which have been noted under "Microscopy" from time to time in the "Journal of Science," has proved eminently successful in rendering structural details more evident. Those portions consisting of tissues hardened by much secondary deposit absorb the dye with avidity, and in the washing process part with it but slowly, so that the simpler tissues are deprived entirely of their colour before the hard parts yield up theirs; careful staining with another dye follows, and the effects of differential colouring are very apparent. Some operators have used three and four colours with great success.

M. G. de Plessis* recommends bichromate of potash for the preservation of delicate marine organisms, such as polypes, *Medusæ*, *Salpæ*, &c. The solution can be made in either fresh or salt water, and a weak solution answers well, exact proportions

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being of but little moment. A specimen of *Medusa aurita* has kept well a whole year, and its beauty and transparency leave nothing to be desired. The solution has only one inconvenience, it permits the development of mould; but this can be prevented by the addition of a few drops of phenic acid or phenic alcohol. Another convenient salt is permanganate of potash, acting very much like osmic acid, clearing away the protoplasm and bringing out the minutiæ and showing nuclei, outlines of cells, &c. It can be dissolved in sea-water, and should be used as a saturated solution either in sea or fresh water. This solution kills small organisms at once. They are left in it from thirty minutes to an hour, then withdrawn and placed in alcohol, after which they can be made transparent with turpentine and mounted in Canada balsam. According to the author it effectually replaces the costly and somewhat dangerous osmic acid.

We learn from M. Reimann's "Färber Zeitung" that two new green dyes have been introduced into practical use; the *Vert acide* of A. Poirrier, of Paris, and the Victoria green of the Baden Aniline Company. The price of the latter is only 16s. per kilo.

The red azo-colouring matters are fast superseding cochineal in the flannel dye-works of Saxony. They have the advantage of not being injured by washing.

M. Aimé Girard has reported to the Société d'Encouragement pour l'Industrie Nationale on M. Kuhlmann's method for recognising the composition and measuring the volume of the gases and acid vapours given off by the chimneys of chemical works. By means of this arrangement a manufacturer can at any hour inform himself concerning the nature of the gases traversing his chimney. To establish the composition of the chimney gases and to detect, *e.g.*, the presence of hydrochloric acid therein, M. Kuhlmann introduces into the shaft a glass tube which communicates with a series of test-tubes, at the end of which is a cistern of water which acts as a respirator. The flow of water compels the gas to traverse the series of test-tubes, the first of which contains caustic soda coloured with litmus. Then follow solutions of barium chloride and silver nitrate. The dimensions of the cistern are such that five or six hours are required for the total efflux of the water which it contains, and the strength of the alkaline liquid coloured blue is such that in the regular course of work five or six hours are required to turn them red. An earlier colouration gives immediate warning. M. Kuhlmann's method of measuring the total volume of gases escaping is as follows:—When he wishes to know the speed of the gases he introduces at the bottom of the chimney a certain volume of a strongly coloured gas, such as hyponitric acid, which accompanies the colourless gases up the chimney and presents itself along with them at the top. Knowing then the volume of the chimney and the mean temperature it is possible to calculate from the time which has elapsed the quantity of gas emitted.

Artificial benzoic acid is at present manufactured in large quantities from the naphthalin that is abundantly found as a by-product in the gas works.

The efficiency of creosote as a preservative of timber against the ravages of the teredo has, remarks the "Engineering and Mining Journal," been signally established by the recently-published report of a commission appointed by the Royal Academy of Sciences of Amsterdam to make a thorough investigation of the subject. This commission selected several of the ports of Holland in which to conduct their experimental trials, and subjected to their tests oak, red-fir, common fir, and pine, in pieces about 3 feet long and 12 inches square. They found that all external applications, such as coal-tar, paraffin varnish, mixtures of tar, resin, sulphur, &c., were absolutely worthless. Mechanical protection, by the use of nails, was found to be only partially efficacious, and, with the use of copper or iron sheathing, too expensive for ordinary use. Impregnation with various materials was also fully experimented upon, and, as against this element of destruction, with the single exception of creosote oil, all proved to be either completely or almost worthless. In this category are named sulphate of copper, copperas, acetate of lead, salts of mercury and arsenic, soluble glass, chloride of calcium, and paraffin oil. Only the blocks treated with creosote oil were found at the end of two years to have remained uninjured. The commission thereupon draw the conclusion that the only effective preservative agent for timber against the depredations of the marine boring-worms is creosote properly applied and of good quality.

According to C. Fürstenau in the "Chemiker Zeitung" the Austrian ultramarine manufacturers sophisticate their colours with three parts of gypsum, and lest the colour should appear too pale it is further mixed with glycerin or glucose or a mixture of both. This keeps the powder damp and renders the colour apparently deeper.

Great industrial activity is being displayed by the German Distiller's Association. At a general meeting it was resolved to establish and maintain a chemical laboratory, an experimental distillery, a school of distilling, a trade journal, a glass-blowing establishment for the manufacture of normal hydrometers, and an office for general intelligence.

It is stated in "La Lancette Belge" that Mr. Edison has invented an ink which gives raised characters upon paper capable of being read by the blind by touch.

The formation of mannite in beer is always a mark of the want of cleanliness and is particularly promoted by decaying wood. In such cases the sugar present enters not into the alcoholic but the mucic fermentation.

Dr. Upmann, in "Chemiker Zeitung," in consequence of some experiments pronounces oxalic acid to have a harmless effect on dogs. Dr. Pfeiffer, in reply, points out that the stomach and intestines of dogs generally contain considerable quantities of calcium phosphate by which the oxalic acid would be converted into calcium oxalate, an inoffensive salt.

Geology.

M. W. H. Hermite, in a paper read before the Academy of Sciences, concludes that the form of the earth is due not to a previous condition of igneous fluidity, but mainly to the configuration of its seas. The remarkable polar flattening of Mars is due, according to his hypothesis, to the different distribution of land and water upon the surface of that planet. Volcanic phenomena he finds also incapable of being referred to the existence of a central fire, or even to the presence of a sea of lava of small extent.

The First Part of Vol. vii. of the "Proceedings of the Yorkshire Geological and Polytechnic Society" contains a number of useful papers. Mr. Sorby gives an account of his new method of studying the optical characters of crystals by looking through them with a microscope at a circular hole or rectangular grating. The Rev. J. F. Blake communicates a paper on the geological history of East Yorkshire. The Rev. E. M. Cole describes the red chalk of the East Riding, Lincolnshire, and Norfolk, which lies at the base of the white chalk and is free from flints. Mr. J. W. Davis, the indefatigable Secretary of the Society and Editor of the "Proceedings," contributes an account of the fish-remains found in the coal measures and the evidence which they afford of fresh-water origin. He shows that the coal was deposited in a series of pools, into which the vegetable matter was carried whose decayed remains form the coal, and when mixed with the mud simultaneously brought down the "hubb," or black bituminous shale. In this, as well as in the coal, large numbers of Cœlacanths have been discovered, as well as Ganoids and Elasmobranchs, though much more sparingly.

We learn from the "Engineering and Mining Journal" that a resolution of thanks to Prof. Hayden for his "accurate and comprehensive survey of the State of Colorado," passed the Legislature of Colorado on January 14th, and upon which Senator Gaussion remarked: "These reports, coming from a scientific and authoritative source, do more to answer and satisfy the inquiries of capitalists than every thing else. They tell the world what the great Western country is made of. The Western domain of the United States is, to-day, the glory of the nation."

Metallurgy.

In a paper "On the Relations between the Chemical Composition and the Mechanical Properties of Steels" (Bull. de la Soc

Chem. de Paris), M. J. Deshayes says that carbon renders steels rigid and elastic, increasing their elastic tension, but their resistance to rupture diminishes if 0·500 is exceeded. Manganese renders steels rigid and elastic, and increases their elastic tension, but the elongation and contraction remain considerable, which gives a good resistance to a shock. Silicon plays the same part as carbon, rendering steels hard, and slightly diminishing elongation. Sulphur decreases the breaking strain and the resistance to a shock. Phosphorus renders steels deficient in body, and, if its proportion exceeds 0·250 per cent, fragile on receiving a shock. Chrome acts like manganese, but more energetically.

According to the "Revue Industrielle" a metal has been extensively produced in France which is a combination of iron and steel. The two metals are run separately into a mould divided into two parts by a thin plate of sheet iron, when the whole becomes welded together. The new metal is particularly adapted for armour-plating, anchors, and safes.

Physics.

The Committee appointed to receive subscriptions to present a bust of Mr. William Spottiswoode, Pres. R.S., to the Royal Institution as a testimonial of his valuable services as its Treasurer and Secretary successively, have engaged Mr. Richard Belt as the sculptor.

On behalf of the Committee of Economical Arts, M. le Compte du Moncel has presented to the Société d'Encouragement pour l'Industrie Nationale a report on M. E. Regnier's electric light regulator. The Committee decide that M. Regnier has solved the problem in question. His arrangement has been successfully tried at the station of the Northern Railway, and in M. Breguet's workshop, where it has acted for some hours with regularity under the influence of the current of a small Gramme machine.

A remarkable case of cohesion, or the welding of two metals at a temperature far below the melting-point of either of them, has lately been noticed by Mr. Charles A. Fawsett, of Glasgow, and by him reported to Sir William Thomson. If a piece of silver, 1 centimetre square, is heated on the inverted lid of a porcelain crucible, to about the temperature of 500° C. (932° F.), and the end of a thin platinum wire is brought into contact with it, the two metals will be found to have welded to that extent that the silver may be raised from the lid, and will remain attached to the platinum wire when cooled off. Mr. Fawsett reports that other metals—copper and aluminium, for example—will likewise adhere to silver, though the experiment is less striking than in the case of platinum.

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